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MICHIGAN STATE UNIVERSITY

AGRICULTURAL EXPERIMENT STATION

EAST LANSING

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THE QUARTERLY BULLETIN

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MICHIGAN STATE UNIVERSITY
AGRICULTURAL EXPERIMENT STATION
EAST LANSING

L. M. TURK, DIRECTOR
R. J. ALDRICH, ASSISTANT DIRECTOR
M. T. ALLEN, EDITOR

MECHANIZING THE HARVEST OF RED TART CHERRIES

By J. H. LEVIN, H. P. GASTON, S. L. HEDDEN and R. T. WHITTENBERGER

MICHIGAN'S AVERAGE ANNUAL production of red tart cherries is approximately 71,000 tons. The average "farm value" of this crop is almost $10 million. New York, Wisconsin, Pennsylvania, Oregon, Utah, Washington, Colorado and other states produce enough additional cherries to make the average U. S. production about 130,000 tons, the "farm value" of which is approximately $20 million.

Compared to other tree fruits in size cherries are relatively small, and hand picking is slow, tedious work. It normally takes about 10 times as many man hours to pick a ton of cherries as it does to harvest a like amount of apples, peaches or pears. The fact that the season is short and per-worker yield comparatively small means that large numbers of pickers are required.

Records kept by the Michigan Employment Security Commission show that it takes about 45,000 workers to harvest the Michigan crop. Sufficient local help is not available in cherry producing areas, and when harvest time comes it is necessary to recruit approximately 35,000 pickers from other parts of Michigan, other states and foreign countries. In the past, these workers and the ones who served other cherry producing states came regularly and followed well-defined routes. Many of the pickers, however, who formerly came during the harvest season have found or are finding year-around employment which eliminates them from working as harvest hands. This means that the streams of migrant pickers once flowing through the cherry producing areas of the United States are rapidly drying up.

While the supply of domestic help was once adequate, the problem has become so acute that it is now necessary to bring in workers

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from foreign countries. Many of the pickers (both foreign and domestic) lack experience and tend to be incompetent. This means that they require more supervision than did the migrants. In spite of this fact, they demand improved housing and higher wages.

At present, approximately half of the total amount of money spent to produce a crop of cherries goes for harvesting. Costs are almost sure to go still higher if human pickers continue to do the work. A less expensive and more effective means of harvesting will have to be found if the industry is to prosper.

Mechanization has solved other fruit production and handling difficulties and this approach appears to offer the only reasonable hope of providing an answer to cherry harvesting.

PURPOSE OF THE WORK

The purpose of the work here reported was to develop equipment and methods that would 1) reduce the number of human pickers required, 2) lower picking costs and 3) help to maintain on-the-tree quality.

HOW THE STUDY WAS MADE

The experimental work was started during the 1956 harvest season when a variety of hand and pole shaking methods were tried. The object was to develop a quick and effective means of separating red tart cherries from the trees on which they grew. None of the methods tried that year proved satisfactory.

In 1957 several types of mechanical shakers and a cloth-covered metal frame were used in separating and collecting the fruit. Although they were more effective, the shakers and the collecting units still left much to be desired.

Early in 1958 a tractor-mounted hydraulically-activated boom-shaker[1] that had been developed in the West for harvesting nut crops was made available for experimental use. It proved the most effective yet and enabled operators to separate in seconds amounts of fruit that had formerly required minutes. Improvements were made in the design of the fruit collecting units and the results achieved in the experimental orchards led to the conclusion that mechanical picking was ready for trial under commercial conditions.

[1]Manufactured by Gould Brothers, Inc., San Jose, California.

During the 1959 season, hydraulic boom-shakers and several types of collecting units were tried in commercial cherry plantings. Several orchards were involved and trials were conducted in Michigan's principal cherry producing areas. The 3,000 trees harvested with machines yielded more than 150,000 pounds of fruit. Time and cost studies were made, yield records were kept and quality studies were conducted both in the field and at the processing plants where the machine-picked fruit was packed.

HANDPICKING METHODS ANALYZED

The Method. Cherries have been picked by hand for many years. In this method a picker usually accumulates several cherries in his hand and then transfers them to an 8 or 10-quart pail held at waist or chest height by web straps. Some cherries are stripped from the trees with the fingers and permitted to fall directly into the picker's pail. Although many cherries are picked from the ground, ladders must be used to harvest most of them. Picking usually requires from 6 to 10 settings of the ladder in each tree. The harvested cherries are usually carried to an orchard trailer or truck where they are poured into lugs, or tanks containing cold water. Some "field sorting" is usually done as the fruit is poured from the pickers' pails. When a load has been accumulated it is hauled to a receiving station or processing plant.

Picking Rates. Performance of pickers varies widely. The average worker harvests about 300 pounds per day for which he is paid a piecework rate of about 2½ cents per pound. When the crop is light, the pickers usually demand higher rates. On the average, a picker drops or spills about 4 percent of the cherries and leaves approximately 1 percent on the tree. This means that the total amount of fruit recovered is about 95 percent.

Damage to Fruit and Tree. Most pickers bruise fruit rather severely, which leads to scald and other blemishes which lower grade and impair keeping quality. Setting ladders and climbing through the trees cause damage to both trees and fruit.

Costs. The ladder, pails and straps used cost about $15 and seldom last more than five years. When equipment, housing and supervision costs are added to what is spent for labor, the total cost of harvesting is approximately 3 cents per pound.

MECHANIZATION—EQUIPMENT AND METHODS

Separating Equipment

The first step in mechanical harvesting is the separation of the fruit from the tree. It was found that selective picking (choosing the individual fruits to be harvested) was impractical. Early in the trials it was found that cherries could be removed by striking or shaking the limbs.

Handshaking—A variety of hand and pole shaking methods were tried in 1956. These included handshaking limbs of various sizes, using hand-held pole shakers (See Fig. 3 page 10) with various types of hooks at the ends, and short lengths of rubber hose to strike the branches. Although cherries could be separated from the tree by these methods, the work was exhausting and the methods were impractical.

Hand-held Mechanical Shakers—During the 1957 season, several types of mechanical shakers were tried. These hand-held units were hooked to or held against individual limbs (See Fig. 4 page 11). Because of the weight and the fact that it was often necessary to hold the units at shoulder height, the work also was exhausting. Much of the shock was transferred to the workers' arms adding to the difficulty. Only small branches could be picked successfully in this way and production rates were low.

Boom-Type Shaker—In 1958 a tractor-mounted hydraulically-activated boom-shaker was tried (Fig. 1). This unit consisted of a tractor-mounted boom with a claw (clamp) at the end (Fig. 2). It could be maneuvered so that the claw could be closed on main scaffold limbs. Once in position the operator could shake the limb by activating the boom. Under favorable conditions this was the most effective means tried and enabled workers to separate approximately 95 percent of the fruit. Production rates and costs are discussed later in this report.

The best method of operation was to back the boom past the first tree in a given row. It was then moved forward into this tree and attached, in turn, to each of the main scaffold branches. In making the attachments the tractor remained in approximately the same position. When the first tree had been finished, the tractor was backed past the second tree in the row and then moved in as before. Subsequent trees were handled in the same way until the row had been completed.

Strokes of ½, 1, 1½ and 2 inches were tried. In each case the fre-

Fig. 1. This type of tractor-mounted boom shaker and canvas-covered collecting unit was used experimentally in 1959.

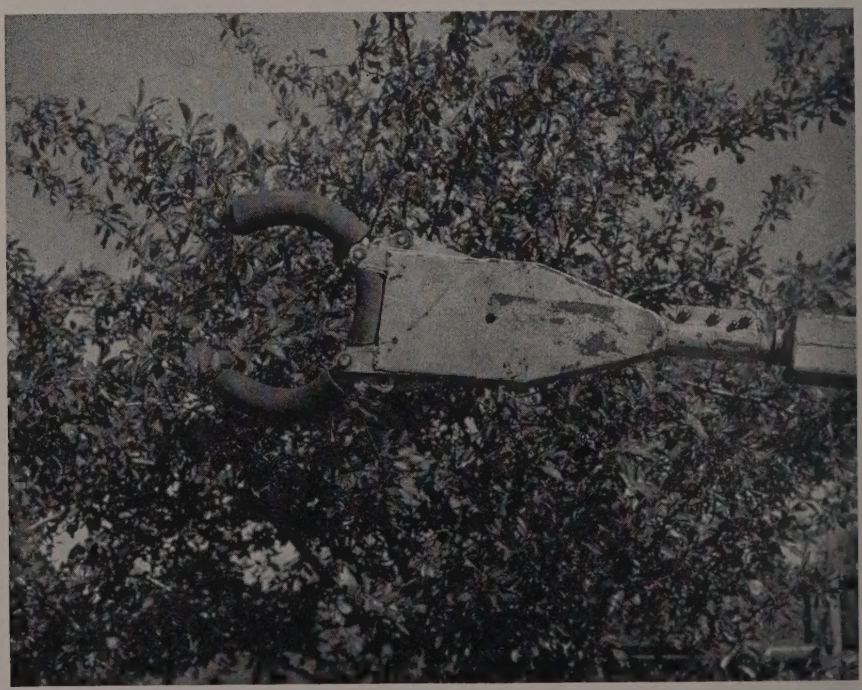

Fig. 2. A close up of a rubber covered "claw" by means of which the boom shaker was attached to scaffold branches. It could be opened and closed.

quency was varied from 500 to 900 cycles per minute. Best results were obtained when a 1½-inch stroke was used at 800 cycles.

Shaking periods of from 3 to 5 seconds gave the best results. Longer periods did not increase the yield but did separate more trash, increase the amount of bruised fruit and cause more bark damage.

In harvesting heavily loaded limbs shaking time should be broken into two or three 1- or 2-second intervals with a short period between each of them. This allows the cherries to roll off the collecting surface and thereby avoids undue strain on the collecting units and helps minimize pocketing and reduces bruising.

The claw should be attached to a limb in such a way that the angle between it and the boom is 90° or as near this as possible. To make such an attachment, however, is not always practical. When the angle deviates from 90°, a force is created which may cause the claw to slip and damage the bark.

The points at which attachments should be made depend upon branch size, distribution of fruit, visibility and the angle which the limb makes with the boom. Generally speaking, the best results are obtained when attachments are made just below the lowest major lateral branch on a given scaffold branch.

Pressure exerted on the branch must be great enough to keep it from slipping, but not so great that it causes damage. Optimum pressure depends on the age of the wood, the size of the limb and the construction of the claw. The pressure on the claw of the shaker used in the trials could be set from 800 to 1,500 pounds per square inch. A setting of 1,200 p.s.i. was used. This proved satisfactory in most instances.

Bark damage due to slippage or pressure of the claw varied from none to quite serious. Some growers feel that while it is objectionable it is not particularly harmful. Others say that the cumulative effect of attachments made at the same point in successive years might prove quite serious. Bark damage can be prevented by wrapping attachment points with cloth, belting or rubber. Research is being conducted to develop a claw that will eliminate all or most of the damage. Studies are also being made to determine the seriousness of the bark damage.

The use of a boom-shaker does not appear to cause root damage. Most attachments were made from 6 to 8 feet above the ground. When the "shake" was applied, that part of the tree which was above the ground absorbed most of the shock and roots did not appear to suffer any ill effects.

Collecting units used with a boom-shaker usually extended from 10 to 12 feet from the trunk of the tree. The diagonal distance to a corner may be as much as 17 feet. Therefore the boom must extend for at least 17 feet in front of the tractor.

Maneuvering a tractor-mounted boom is difficult and involves careful steering and numerous changes in direction. Tractors equipped with power steering and reversible (shuttle) gears are recommended.

Other Shakers. Many growers and orchard equipment manufacturers have become interested in the possibilities of mechanization. Several units have been made and others are being planned. Although relatively small, inexpensive self-powered shakers might lack the capacity needed by large commercial growers, they could probably be used to advantage in small orchards, young plantings, hilly terrain and closely-spaced blocks. Some shakers being developed may prove practical, and certainly existing equipment will be improved.

Collecting Equipment

A satisfactory method of collecting the fruit is necessary. An effective collecting unit must catch the falling fruit and convey it into an initial container with a minimum of damage. The unit must be mobile enough to be easily moved from tree to tree as rapidly as the shaker is moved.

Six types of collecting units used in commercial plantings are described below. It is hoped that a discussion of these units will enable growers to select or develop units which will suit their needs.

Light Weight Rectangular. The collecting unit used in 1957 for preliminary trials consisted of a 12 x 24-foot piece of 6 ounce canvas, supported at the four corners and at the mid-point of the side next to the tree when the unit was in use (Fig. 3). This unit sloped away from the tree to an opening through which the cherries flowed into lugs placed on the ground. Two units were required to collect the fruit from a tree.

This frame was useful only in harvesting high-headed trees, since it could not be moved under a low-headed tree. The light weight canvas and lack of a sufficient number of supports allowed cherries to "pocket". It proved much too light for use under commercial conditions.

Fig. 3. The surface of this collecting unit sloped away from the tree and could not be used when there were low branches. To operate the hand-held shaker shown here was hard work.

Semi-Circular Folding. A semi-circular collecting unit which could be folded while being moved was used in 1958. It sloped toward a central drain hole located close to the trunk of the tree (Fig. 4). The fruit flowed onto a hand-cranked belt conveyor 8 in. wide which carried it to a point where it was transferred to lugs. The 8-ounce canvas was supported by 10 trussed booms made of thin-walled conduit, each of which was pivoted on the frame near the tree. When it was moved from tree to tree the booms were swung to positions parallel to and close to the sides of the conveyor. This made it easier to maneuver between closely planted trees. An elastic apron attached to the two outside booms formed a "seal" around the tree when the frame was in position.

The unit was supported by three rubber tired wheels 16 inches in diameter. This made it relatively easy to move the unit from tree to tree. The radius of the semi-circular collecting unit was 11 feet.

The cherries drained well with a minimum of pocketing. The high outer edge (5 feet above the ground) made it difficult, however, for the shaker operator to make the low limb attachments sometimes desirable. Two semi-circular frames were used to collect the fruit from one tree. Using two conveyor-equipped frames made it necessary to fill containers at two points on opposite sides of the tree.

Another semi-circular unit, the sides of which directed the fruit into a conveyor, was built in 1959 (Fig. 5). The boom could be attached at points as low as 24 inches from the ground. The collecting unit could be folded to facilitate moving.

Both of the folding units tried required considerable time to fold, move, position and unfold. This characteristic proved undesirable.

Rectangular Collector with Conveyor. Collecting units that could be moved straight down the row were built and tested in 1959 (Fig. 6). Each of the frames was 10 x 20 feet. They were constructed of lightweight tubing and mounted on rubber tired wheels 16 inches in diameter. The slope of each frame was adjustable from the horizontal position to 25°. Two of the four wheels on each unit were castered to facilitate steering. One of the two frames in each set had a hand-

Fig. 4. This semi-circular folding unit was an effective fruit collector, but to fold and unfold it required time and effort. A hand-held mechanical shaker is being used by a worker on a "steel squirrel."

Fig. 5. This semi-circular, low profile unit permitted the shaker operator to make low attachments. However, the folding feature proved undesirable.

Fig. 6. This experimental collecting unit has a conveyor along its lower edge. It has been pushed into position and the other half of the set is being moved in.

cranked conveyor which ran along its lower edge. This was 8 inches wide and 20 feet long. The unit which did not have the conveyor was provided with bridging flaps (one for each side of the tree). They were placed so that they rested on the edge of the conveyor (Fig. 7). All of the separated fruit rolled into this conveyor and was directed into lugs. When the collecting frames were in the "up" position the sides were about 5 feet high at the outer edges. The ends of the frames, however, were open and the shaker could be moved in at a relatively low angle.

Considerable difficulty was encountered with the long narrow conveyor. At times the belt did not track properly, making the hand crank hard to operate.

The 6-ounce twill canvas covering the frames could not be stretched tightly enough to prevent pocketing.

Bridging flaps were not effective in channeling the fruit into the conveyor.

Rectangular Units with Lug Rack. A rectangular collecting unit, similar to the one described above, was made by Mr. Raymond Pappe of Ludington, Michigan. It included two 10-foot lengths of skate roller conveyor instead of the belt conveyor (Fig. 8). Separated cherries

Fig. 7. The "bridging flap", which is part of the right-hand unit, is being placed on the edge of the conveyor which is a part of the left-hand unit.

Fig. 8. A collecting unit with a skate roller conveyor along its lower edge. The conveyor holds cherry lugs when the units are being used.

rolled off the collecting unit directly into cherry lugs placed on the roller conveyor and extending along the lower edge of one of the frames. A treated 12-ounce canvas was used to minimize "pocketing." A U-shaped "cut-out" was made in the other frame. This opening was big enough to fit around the trunks of the trees. A hump (18″ wide, 8″ high and 3′ long) also was built into the frame, at the cut-out, to deflect the fruit around the tree trunk and into the lugs. The edge of the frame overlapped the lug boxes on the conveyor. The U-shaped cut-out had no adjustment to compensate for large tree trunks or low-headed trees. When these conditions were encountered, the edge of the collecting frame would not reach the lug boxes and extra lugs had to be placed on the ground to catch cherries which would otherwise have been lost.

All four wheels on these units were castered. This facilitated maneuvering around the trees but caused some steering difficulties when the frames were moved considerable distances.

The two wheels farthest from the tree on each frame had extended swivel shafts on which the edge of the frame could be moved up and down to adjust the angle of the surface. Using lug boxes to collect the fruit caused bruising when the cherries struck the sides of the lugs.

Rectangular Skid-Mounted Frame. Rectangular shaped collecting frames mounted on skids were used in two commercial harvesting operations in 1959. The 12 x 24-foot frames were constructed of 2-inch aluminum tubing and covered with 10-ounce untreated canvas (Fig. 9).

Fig. 9. This skid-mounted collecting unit was used effectively in one commercial orchard during experimental mechanical harvesting of cherries.

The canvas was stretched on the frame by using tent rope tighteners. Both halves of the set had fruit-deflecting humps at the middle of the lower edges. The collecting frames sloped toward the trees and emptied into specially made troughs (boxes) lined with canvas. These troughs were 5½ feet long, 18 inches wide and 6 inches deep. The canvas "liners" were attached to the "long" edges in such a way that they did not touch the sides or the bottom of the box. This provided a yielding surface which the cherries struck as they rolled into the trough. The containers had hinged doors at one end that facilitated emptying.

Fruit in the troughs was emptied into lugs or tanks containing cold water. This was performed after the tree had been finished and the collecting units moved ahead.

This collecting equipment was simple and had no moving parts. It

cost less than that of the frames provided with conveyors. The troughs were wide enough to allow some latitude in placing the frames under low-headed trees.

The light-weight frames on skids worked well in flat, clean cultivated orchards, but the crew was tired at the end of an 8-hour day. Skidding the frames and lifting the troughs was hard work. The wood troughs used in the trials were heavy and cumbersome. Collecting units made from metal tubing and canvas are much lighter and should prove just as serviceable. The untreated canvas tended to shrink at night and stretch during the daylight hours. This required frequent rope-tightener adjustments.

Rectangular Leg-supported Frames. Simple non-rigid rectangular collecting frames, 12 x 24-feet, were made and used in two commercial harvestings. One set of frames was made from steel tubing, the other one from 1-inch galvanized pipe. In each case the canvas was laced directly to the frame. The outer edges of the frames were supported by hinged metal legs (Fig. 10). The surfaces sloped toward and rested on a row of lugs placed under the trees to be harvested. These units were comparatively light and deflected the separated fruit directly into lugs. They were lifted and carried from tree to tree. Although

Fig. 10. The outside edge of this cherry collecting unit was supported by adjustable metal legs.

the frames were relatively light, lifting and carrying them frequently proved to be hard work.

Flexibility of the frames caused the canvas to pocket and the lacing of the canvas made it difficult to take up the slack.

Placing the lugs on the ground was unsatisfactory when trees were mounded or the ground uneven.

No provision was made to deflect the fruit around the tree trunk. This resulted in some loss of fruit. Extra labor was required to place the lugs at the next tree before the frames were moved.

Handling Equipment

"Handling" the fruit begins when the separated cherries have moved from the collecting unit into a lug, trough, conveyor or other container and ends when it arrives at the processing plant. "Handling equipment" means conveyors, lug tanks and/or other devices used during the handling operation.

All commercial fruit handling damages the product. Cherries are tender fruits and must be handled with care to maintain acceptable grades. Although injury may occur at any time during the 12- to 24-hour period which usually elapses between picking and processing, the most critical period is the 2-hour interval immediately following the time the cherries are separated from the tree. During this time, friction, temperature of 60°F. or higher and/or pressure cause scald and other types of injury which affect appearance, quality and grade.

Effective cherry handling equipment must produce a minimum of friction and pressure on the fruit. Lowering the temperature of the fruit increases the effectiveness of the equipment.

In an effort to develop handling equipment which provides all, or at least most, of the desirable characteristics mentioned above, the six combinations of equipment described below were tried.

Lugs. When lugs were used, a line of them was placed side by side on the ground (in the row) under the tree to be harvested or on a rack built along the lower edge of one of the collecting units (see discussion of "Rectangular Units With Lug Rack" page 13). When the lugs were placed on the ground, two inclined plane collecting frames were placed so that the cherries which fell rolled into the lugs. Best results were obtained when the tree ahead of the one being harvested was "lined" with lugs so that the collector could be moved ahead as soon as a tree was finished. When the units were moved, the cherries in partial-

ly filled lugs were poured together and empties moved ahead. Filled lugs were left in the row. When a load had been accumulated, they were placed on a truck and moved to the processing plant.

Troughs and Lugs. Wooden boxes, "troughs" were 5½ feet long, 18 inches wide and 6 inches deep. They were provided with handles and a hinged door at one end (Fig. 11). When these containers were used, two units were placed end to end (in the row) on each side of the trunk of the tree to be harvested. The cherries rolled from the collecting units into the troughs. When the frames had been moved to the next tree (under which a second set of troughs had already

Fig. 11. This is one of the troughs in which cherries were collected. The handles and hinged door facilitated emptying. A trough of the length shown here proved unwieldy and was replaced by two 5½ foot units. Note that the amount of leaves and twigs which came off with the cherries is relatively small.

been placed), the filled units were emptied into lugs and moved to the tree ahead. When a load of filled lugs had been accumulated, they were loaded onto a truck and moved to the processing plant.

Conveyor and Lugs. When this combination of equipment was used, a hand-cranked conveyor was attached to the lower edge of one of the collecting units (Fig. 12). The cherries which fell onto the unit rolled into this conveyor. Once on the conveyor the cherries were moved to the end and transferred into lugs, then transported to the processing plant.

Fig. 12. The hand-cranked conveyor attached to the lower edge of one of the collecting units enabled the workers to move the cherries to a point at which they could be transferred to lugs.

Lugs and Tanks of Water. The fruit was collected in lugs as outlined above. Cherries were poured from the lugs into tanks containing cold water (Fig. 13). Tanks were moved to the processing plant by means of trailers or trucks.

Troughs and Tanks of Water. In this case, the cherries were collected in troughs as described above, but instead of being emptied into lugs the fruit was poured into tanks containing cold water and transported directly to the processing plant.

Fig. 13. This 4′ X 4′ X 4′ tank can be moved through the orchard with lift equipment. Using such a tank makes it possible to cool mechanically harvested fruit quickly.

Conveyor and Tanks. In this system, cherries are collected in a conveyor, but instead of being transferred to lugs they are moved directly from the conveyor to tanks containing cold water and taken to the processing plant on trucks.

Handling Equipment Compared. The most important factors to be considered in deciding the best combination of equipment are: 1) Effect on quality, 2) labor cost in using the equipment and 3) difficulty of physical labor involved.

If care is taken, mechanically harvested cherries can be handled in lugs or troughs with a minimum of damage. However, the workers who move and stack the filled containers in hot weather tend to become tired, careless and difficult to manage. Advantages of water handling[2] (see discussion on "Quality can be maintained" page 21) are so significant that "conveyor and tanks," "troughs and tanks" or "lugs and tanks" are ranked one, two and three respectively.

[2]See U.S.D.A. Circular No. 891 entitled, "Grower handling of red cherries" for a discussion of this subject.

Using conveyors adds to the cost of the equipment. However, the cost is more than offset by manpower reduction. Not only do conveyors eliminate from one to three workers, but they also minimize the hard work of lifting and carrying lugs and troughs.

QUALITY CAN BE MAINTAINED

The value of a harvesting method depends on how it affects fruit quality and efficiency. There is no market for undergrade fruit. For this reason quality maintenance was emphasized. Checks were made at several points during harvesting, handling and processing. Bruising was measured both subjectively and objectively. Grade scores recorded were supplemented, whenever possible, by scores taken by Federal-State inspectors. Causes for down-grading were ascertained and, when feasible, corrective changes were made.

Unlike hand pickers, mechanical shakers cannot be selective. They separate practically all of the cherries produced by a given tree. The grade of mechanically harvested cherries is affected by 1) the quality of fruit on the tree, 2) the amount of mechanical injury which occurs during harvest and handling, and 3) the number of stems which remain attached. Although the presence of a stem on a cherry does not affect its quality, it must be removed during the processing operation. Because of this, stems are counted as defects in determining grade.

Grade Scores Analyzed. Analysis of representative grade scores may prove helpful to growers considering mechanization. Table 1 gives grade scores of unsorted, mechanically harvested cherries from four orchards in West Central and Northwest Michigan. Scores ranged from 79 to 95.

Orchard A, the first one harvested in 1959, was graded 84 and the biggest defect was bruising. Seven percent were seriously bruised. Injury was due to faulty operation of collecting equipment. Bruises were caused by 1) pockets in the collecting unit, 2) handling necessary when cherries piled up at poorly designed deflectors, 3) faulty operation of the conveyor belt, 4) careless filling of lugs, and 5) hard surfaces of parts of the collecting unit on which some of the cherries fell. Approximately 5 percent of the collecting surfaces were made of wood, metal or hard rubber. In subsequent tests improvements

TABLE 1—Grade scores (a) of unsorted (b) mechanically-harvested red tart cherries

Grade factor	Orchard			
	A(c)	B(d)	C(e)	D(f)
Harvested cherries which were defective (decay, wind whip, etc.) before separation	Percent 6	Percent 5	Percent 11	Percent 2
Cherries bruised during harvest	7	2	3	1
Cherries harvested with stems attached	3	2	7	2
Grade score	84	91	79	95

(a) Grade scores were determined by the investigators during the 4-hour period following separation. All lots were scored also by Federal State inspectors. In each case the Federal State grades were equal to or higher than those recorded by the investigators.
(b) Data are based on all of the mechanically-separated cherries. When cherries are picked by hand, the workers often discard some of the defective fruits.
(c) Data are based on the averages of 16 2-pound samples from 16 trees chosen at random.
(d) Data are based on the averages of 5 2-pound random samples from the combined fruits from 14 trees.
(e) Data are based on the averages of 15 2-pound random samples from the combined fruits from 15 trees.
(f) Data are based on the averages of 8 2-pound random samples from the combined fruits from 8 trees.

were made. One of the devices used to prevent bruising was a canvas deflector which prevented cherries from falling vertically into the trough.

In orchard B and C, grade scores were adversely affected by inferior on-the-tree quality. Grade cannot be improved by harvesting. It can at best only be maintained. Thus, the highest possible score of unsorted cherries from orchard C was 89 percent. Eleven percent of the cherries had defects such as wind-whip, scars and decay before they were separated. Seven percent of the cherries came off the trees with stems and 3 percent were bruised in harvesting. The resulting grade was 79. The grade could have been raised to acceptable standards by hand sorting.

Good results were obtained in orchard D where unsorted, mechanically harvested fruit graded 95. On-the-tree quality was excellent, bruising was held to a minimum and relatively few of the harvested cherries came off with stems.

In orchards B and D, mechanically harvested cherries were less seriously bruised than commercially hand picked cherries from the same orchard. The opposite was true in orchards A and C.

Trash. The amount of trash (leaves, twigs, stems and other foreign material) was relatively small. It was floated off during the soak

period and posed no serious problem. Old trees yielded more trash than younger ones. Probably first shaking separates trash that has been accumulated during several seasons. Subsequent shaking probably will cause less trash to fall.

Stems. Causes for variation in the number of stems remaining on harvested fruit are not known. In three of the six orchards studied only about 2 percent of the cherries had stems. In the remaining three orchards, however, 7 percent of the mechanically picked fruit came down with stems. In some tests stem attachment was found to vary with the maturity of fruit and the nature of the shaking. The number of attached stems decreased as cherries became riper and mechanical shaking yielded fewer with stems than did manual shaking. The possibility of a relationship between stem attachment and the amount of nitrogen in the soil or tree is being investigated.

In the processing plant, most stems remained attached to the cherries as they were soaked and conveyed along the processing line. The cherries with stems, however, were conspicuous and could be removed during the sorting operation provided, of course, that the percentage was not high. In some tests a mechanical de-stemmer was placed in the processing line. Although this machine removed practically all of the stems, its capacity was limited.

Culls. Attempts to improve quality by removing defective fruit prior to harvest have thus far proved unsuccessful. Although a short preliminary shake removes many of the defective cherries, it also separates a considerable number of high grade fruit. In some instances mechanical shaking enables operators to improve grade, because most of the cherries which do not separate readily (approximately 5 percent) are small, lightly colored and immature.

Bruises. In harvesting cherries with machines, the fruit must be separated, collected and handled. It was found that cherries could be mechanically separated and collected with less bruising than normally occurs when the fruit is picked by hand. In other words, mechanical shaking, falling through the tree, striking the collecting unit and rolling over it to the initial containers caused comparatively little bruising.

Mechanically separated cherries had less stem-end damage than those carefully handpicked. In four tests in two orchards, an average of 88 percent of the handpicked cherries had slight tearing of the

skin, bleeding, and pulled-out pulp tissue at the point of stem attachment; the corresponding value for mechanically harvested fruit was 64 percent.

Scald. Proper water handling minimizes scald and helps maintain on-the-tree quality. The effect of handling machine-picked cherries in water was determined by placing the cherries immediately after harvest in (1) water at 40° - 45° F., (2) water at 55° - 60° F., and (3) lugs at 80° - 85° F. Five hours later at the processing plant the cherries were transferred to a soak tank containing water at 55° F. After being soaked for 16 hours, the amount of scald in the various lots was 1 percent, 6 percent, and 13 percent, respectively. The data are averages obtained by repeating the experiment four times on cherries from two orchards. The lots ranged in size from 20 to several hundred pounds.

Similar results were obtained with cherries harvested by hand pickers. Results show that scald can be inhibited almost completely by proper use of the water-handling. Cherries improperly handled in warm water (70° - 80° F.), however, may exhibit as much or more scald than cherries handled in lugs. Success depends largely on the temperature of the water and the time which elapses between harvesting and cooling. The colder the water and the shorter the time, the better the results.

Processed Samples. Several months after heat processing, sample cans of mechanically harvested fruit were opened and graded. Mechanically harvested fruit compared favorably with hand picked fruit. The color of the fruit which had been handled in cold water was slightly superior to that of fruit handled in lugs. All samples met the legal requirements for U. S. Grade A pack.

MECHANIZATION SAVES TIME, MONEY AND LABOR

Time, motion and cost studies were made of mechanical harvesting in six orchards of 540 trees and the 1,161 lugs of cherries which they produced. Results obtained in the experimental blocks were supplemented by records kept on 2,500 additional trees picked with machines.

Figure 14 shows the per-pound labor cost of harvesting cherries. The number of workers involved varied from 4 to 9, depending on the type of equipment used. The figure shows graphically what can

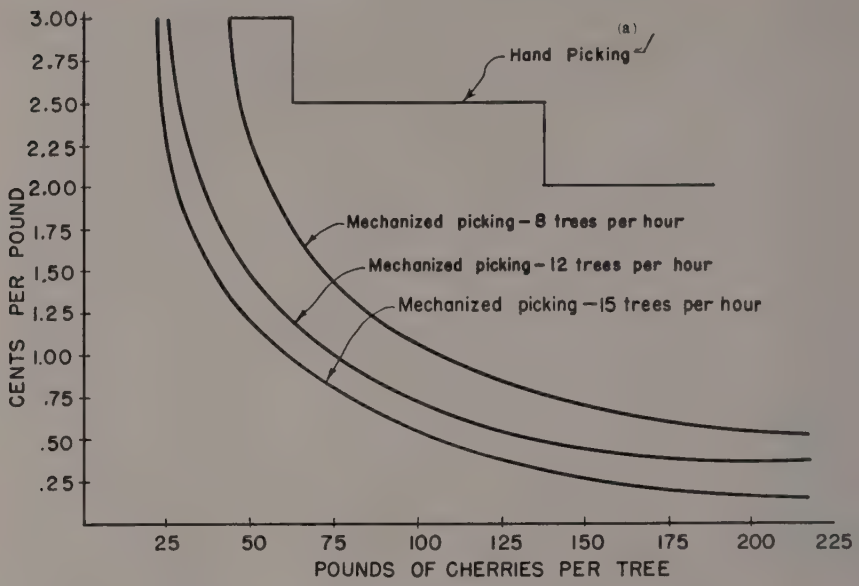

Fig. 14. Calculated per pound labor cost of harvesting cherries (b).

(a) Estimated costs of hand picking—included to make comparisons possible.

(b) Calculations made on basis of a seven-man crew paid $1.25 per hour.

be expected when a crew of seven men is employed. This number was chosen because results indicated that such a crew is large enough to operate with maximum efficiency.

The study showed that it took approximately the same amount of time to shake and collect the fruit from a tree that produced 100 pounds as it did from one that produced 50 pounds. This means that the heavier the crop the less the per-pound cost of harvesting. For example, the per-pound labor cost of harvesting a 4-lug-per-tree crop is about half that of a 2-lug-per-tree crop and approximately a quarter that of a 1-lug-per-tree crop.

The per-pound labor cost is directly affected by the harvesting rate. In orchard C, where the ground was level and the trees high-headed and open, the crew was able to harvest 15.1 trees per hour. In orchard B, the crew averaged 12 trees per hour. In orchard A, where the trees were low-headed and so dense it was hard for the shaker operator to see where he could attach his machine, the average rate was 8.1 trees per hour. Also, the ground cover was so high it interfered with the placing of the collecting units.

Time studies showed that it took from 25 to 44 seconds to make an attachment, shake the limb, release the claw and move to the next branch. Trees that have more than four main scaffold branches take more time and increase per-pound costs. In open trees the time per limb was from 25 to 30 seconds. In dense trees the comparable figures were 40 to 45 seconds. The average number of "sets" (main scaffold branches) on the 540 trees studied was 4.02 per tree.

The average time required to make the attachments and shake the branches in a single tree was 172 seconds. On the average, it took 112 seconds to move the equipment from tree to tree. This means that it took 284 seconds (172 plus 112) or about 5 minutes to harvest a single tree. This rate enabled the crew to do about 12 trees per hour or about 100 trees a day. As pointed out previously, the time required depends on the number of scaffold limbs and the density of the tree and other variable factors. Improved equipment and special pruning should make it possible to do 15 or more trees per hour.

Figure 14 shows the per pound labor cost when trees are harvested by a seven-man crew at rates of 8, 12 and 15 trees per hour. The figures show that increasing the rate pays high dividends.

The labor cost of machine harvesting trees producing more than 50 pounds of cherries is materially less than the cost of handpicking. For example, a grower whose trees produce 4 lugs each (100 pounds), and who harvests them at the rate of 12 trees per hour, pays a labor cost of ¾ of a cent per-pound when the fruit is picked with machines. It is usually necessary to pay hand pickers 2½ cents per pound.

Figure 15 shows the per-pound equipment costs of harvesting cherries mechanically. These figures include depreciation, interest, taxes, insurance and maintenance. Although the equipment should last for more than five years, growers should probably depreciate their harvesting machines on this basis. Improvements will no doubt be made, and the present equipment will probably become obsolete even though it is still serviceable.

The boom-shaker used in 1959 cost approximately $2,700. The cost of the collecting units varied from $300 to $800. Part (⅓) of the cost of the tractor on which the shaker was mounted was also charged to the harvesting operation. In calculating the amounts which appear in Figure 15 a total investment of $4,000 was made. The annual charges for depreciation, interest, taxes, insurance and maintenance came to 30 percent ($1,200) per year. It should be pointed out that

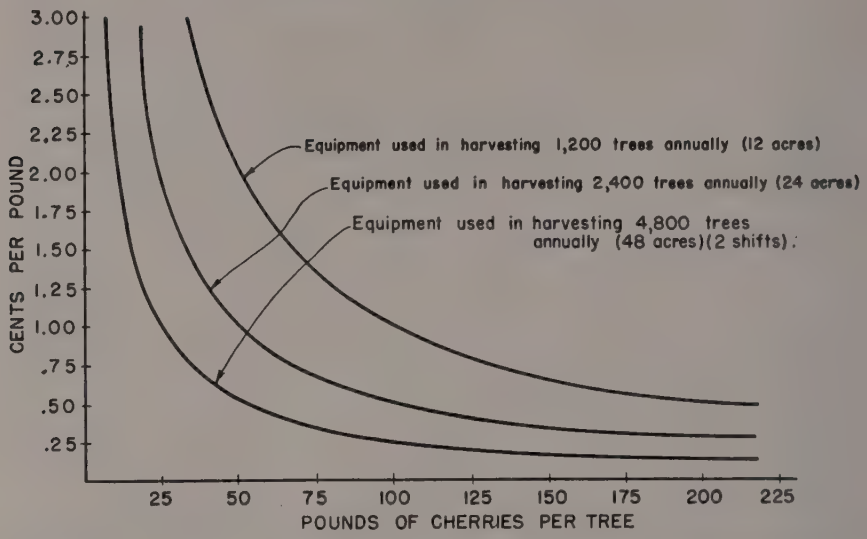

Fig. 15. Calculated annual per pound equipment cost of harvesting cherries mechanically (a).

(a) Depreciation calculated at 20 percent; interest at 6 percent of the average investment; taxes, 2 percent; insurance, 2 percent; maintenance, 3 percent.

the equipment used by the hand pickers needed to harvest a 25-acre cherry orchard costs about $200 annually.

Assuming a production rate of 12 trees per hour, a seven-man crew should harvest 100 trees in an 8- or 9-hour day. If, on the average, the trees produce 100 pounds of fruit, a seven-man crew would harvest as many cherries as 30 to 35 hand pickers. This means that for every 4 or 5 hand pickers only one worker is needed when the cherries are harvested with machines.

The cost of harvesting equipment, per pound of cherries involved, depends on the number of trees and the pounds of cherries harvested during the season. Figure 15 shows the cost when the equipment is used for 24 8-hour days (2400 trees or approximately 24 acres). The figure also shows what would happen if the equipment were used 16 hours a day (two shifts) and also the results that could be expected when used on 1,200 trees — a 12-acre block. The figures show that the equipment should, if possible, be used 16 hours a day. Doing so reduces the per-pound equipment cost by one half.

As in the case of labor costs, equipment costs depended on the number of pounds of cherries per tree. The heavier the crop the less the per-pound cost.

By using Figures 14 and 15, growers can estimate the labor and equipment costs of mechanical harvesting and the number of acres needed to justify the purchase of the necessary equipment. For example, a grower who has 24 acres of trees and a crop which averages 75 pounds per tree would have a labor cost of 1 cent per pound and an equipment cost of .66 cent per pound. This would make a total cost of 1.66 cent per pound as compared to the 2½ cent figure normally paid. Such a grower could not only pay for his equipment in five years, but would also be increasing his returns by .8 cent per pound provided other factors remained the same. He would make an additional saving on housing, insurance, recruiting, etc.

The figures also show that in a 12-acre operation in which the trees produced an average of 75 pounds of fruit the labor cost would be 1 cent and the equipment cost 1½ cent. The total cost would be 2½ cents per pound. In a sense he would just break even. However, he would probably save in recruiting, supervision, insurance and housing.

RESULTS ARE INFLUENCED BY MANY FACTORS

The trials conducted during the past several seasons proved that the effectiveness of a mechanized picking operation is influenced by a considerable number of factors. A short discussion of these factors should lead to a better understanding of the entire subject.

Age of Tree. Young, (less than 10 years) vigorous growing trees are often so dense that it is difficult for the shaker operator to see points at which satisfactory attachments can be made. As the tree grows older the lower limbs tend to be shaded out. This leaves the lower part of the tree relatively open (Fig. 16). An open tree makes it relatively easy for the machine operator to work quickly and effectively.

Pruning. Trees that are to be harvested mechanically should be trained so that they develop relatively high heads and a minimum number (3 to 4) scaffold branches. Low limbs interfere with the placing of fruit-collecting equipment. Branches that touch the collecting surface do not shake enough to cause the fruit to separate. Low limbs should be eliminated early in the life of the tree. Cherry trees begin to open up naturally at about 10 years of age. This tendency can be accelerated by pruning.

Fig. 16. The boom shaker used in the trials proved effective in orchards made up of trees of this type—open trees with three scaffold branches.

Terrain. The collecting devices so far developed work best on relatively level ground. The mound of dirt thrown up in connection with mouse control programs tends to make the placing of collecting devices more difficult. Ruts, erosion and the furrows sometimes left by orchard tools add to the difficulty of maneuvering the equipment.

Planting Distances. The equipment used in the trials worked best when the trees were spaced at least 22½ feet apart. Wider spacing facilitated the work and will probably continue to be desirable until more readily maneuverable equipment is developed.

Interplanting. Interplanted orchards were more difficult to harvest than solid blocks. Moving the equipment through interplanted or-

chards increased the time required to do the work and reduced the maneuverability of the equipment. Apple interplants often have low branches that increase the difficulty of moving the equipment from tree to tree.

Spray Program. It has been known for some time that spray materials affect the ease with which cherries can be separated. Further studies will have to be made, however, before definite recommendations can be made. In the meantime growers should realize that the spray materials they use will affect the results achieved by mechanization. The spray program may also affect the percentage of cherries which separate with stems attached.

Fertilizers. There is some indication that the kind and amount of fertilizer used also affects separation. This problem will also have to be studied before recommendations can be made.

Cover. The equipment so far developed worked best in either clean cultivated orchards or in plantings in which the vegetative cover was not more than 2 or 3 inches high. Thick, tall grass or weeds interfered with the placing of the fruit collecting units, the functioning of the conveyors and the handling of containers.

Fruit Varietal Strains. Although no studies have been made of the affect of varietal strain on separation, it is known that strains affect tree vigor, productiveness and color. It seems likely that this factor may also influence ease of separation.

Other Factors. There are no doubt other factors which will affect the results obtained by mechanization. Growers who are contemplating the use of mechanical pickers not only should take all of the known factors into account, but should realize that there may be others which will affect the results achieved.

EQUIPMENT CAN BE USED FOR OTHER CROPS

The cost figures previously presented were based on using the equipment for harvesting only tart cherries. Actually, producers who have mechanical harvesting equipment may be able to use it on apples, plums and sweet cherries. If they do not grow these crops the machines may be rented to others or used in doing custom harvesting.

Plums. Studies have shown that plums can be harvested by shaking. The harvesting cost is relatively low and the grade of the fruit com-

pares favorably with that of hand-picked plums. A separate report on mechanical harvesting of plums is being prepared and will be available from Michigan State University in the near future.

Apples. The results of some preliminary trials indicate that it may be feasible to mechanize the harvest of apples destined for processing outlets. Several hundred bushels of "juice" apples were harvested with machines and placed in containers at a per-crate cost of approximately 3 cents. Improved collecting units may make it possible to reduce the amount of bruising to the point at which apples that are to be made into baby food or apple sauce can also be harvested mechanically.

Sweet Cherries. Studies on harvesting sweet cherries have been made concurrently with those here reported on tart cherries. The methods and equipment used in harvesting tart cherries were tried on several varieties of sweets. A considerable portion of the sweet cherry crop is harvested (for brining) before it is mature enough to go to the fresh fruit market or to the canner. To separate fruit from the tree while it is in this stage of maturity requires rather violent shaking. This treatment caused considerable bruising. A chemical spray which will loosen the cherries and make separation easier is needed. Of the twenty chemicals tried during the past three years, one shows promise and it is hoped that in the near future the mechanical harvesting of sweet cherries may become a reality.

SUMMARY

In 1956 research was initiated to develop equipment and methods for harvesting red tart cherries that would reduce the number of workers required and lower picking costs.

During the 1956, 1957 and 1958 seasons, various types of shaking and collecting equipment and methods were tried. During the 1959 season, the best combinations of equipment (a boom-type shaker and six different designs for collecting units) were used in harvesting approximately 3,000 trees and 6,000 lugs of cherries in six orchards. Time, motion and cost studies were kept on the harvesting of 511 trees and 1,102 lugs of fruit.

On the average, the equipment used separated 95 percent of the cherries. Most of the fruit left on the trees lacked size, color and maturity.

The grade of unsorted mechanically harvested cherries varied from 79 to 95 percent U. S. No. 1. These results show that acceptable

grades can be obtained when care and proper equipment are used. Mechanical harvesting in conjunction with proper water handling resulted in the best quality.

Total mechanical harvesting costs varied from ½ cent to over 2½ cents per pound, depending on the size of the crop and the rate at which the work was done. Under the conditions existing in many orchards, mechanical harvesting will enable seven men to do the work of 33 handpickers and reduce harvesting costs by one half.

The equipment and methods used proved satisfactory. However, many improvements will no doubt be made in the near future.

The success of a mechanical harvesting operation depends on such factors as age and structure of the tree, cultural practices, equipment used, handling methods and supervision

ACKNOWLEDGMENTS

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The assistance rendered by Alfred Pero of Northeast, Pennsylvania, who conducted mechanical harvesting trials in his orchard and made the results of this work available, is also appreciated.

AUTHORS

J. H. LEVIN, Agricultural Engineer, Agricultural Engineering Research Division, U.S.D.A., provided the liaison between the various agencies and individuals involved in the study. H. P. GASTON, Dept. of Horticulture, Michigan State University, directed the horticultural phases of the trials. S. L. HEDDEN, Agricultural Engineer, Agricultural Engineering Research Division, U.S.D.A., designed and supervised the construction of most of the fruit collecting and handling equipment used in the experiments. R. T. WHITTENBERGER, Biochemist, Eastern Utilization Research and Development Division, Agricultural Research Service, U.S.D.A., conducted the quality control studies made during the course of the investigation.

ECONOMIC ANALYSIS OF THE MICHIGAN POTATO ENTERPRISE

By C. R. HOGLUND and K. T. WRIGHT[1]

Department of Agricultural Economics

MANY PEOPLE, including potato growers, research and extension personnel, and marketing agents have been concerned about the future of the potato enterprise in Michigan. They wonder whether Michigan growers can compete successfully not only with farmers growing other crops in the state but with potato growers in other states. Michigan-grown potatoes consistently sell for from 10 to more than 20 cents less per 10-pound bag than potatoes from Idaho, and a few cents less than potatoes from Maine and other states.

The purpose of this study was three-fold: namely, (1) to determine the costs and returns from potatoes grown in different areas of the state and under different combinations of production practices, (2) to study the organization and production practices of typical potato-growing farms in important potato counties of Michigan and (3) to calculate the effect on investments, expenses and net returns when typical farms are budgeted for changes in organization and production practices. The first phase of this study was published in April, 1958.[2]

Cropping Trends

State Acres and Yields

Potatoes harvested in Michigan reached a peak of 323,000 acres in 1934-35 and since that date has declined consistently up to 1952, with the acreage since then ranging from 50,000 to 65,000 acres (Fig. 1). Comparisons were made of the changes in acres harvested and yield per acre for two 10-year periods: 1928-37 and 1948-57. These changes

[1]The authors acknowledge the assistance of Bernard Brown and Dean Tribby who completed much of the field work. The authors received helpful suggestions from D. L. Clanahan, N. R. Thompson, and E. J. Wheeler of the Department of Farm Crops, and E. H. Kidder of the Department of Agricultural Engineering. The authors also thank the county agricultural agents and the potato growers who co-operated in the study.

[2]Wright, K. T. Potato production costs in Michigan. 1957, Michigan Agr. Econ. Mimeo. 722.

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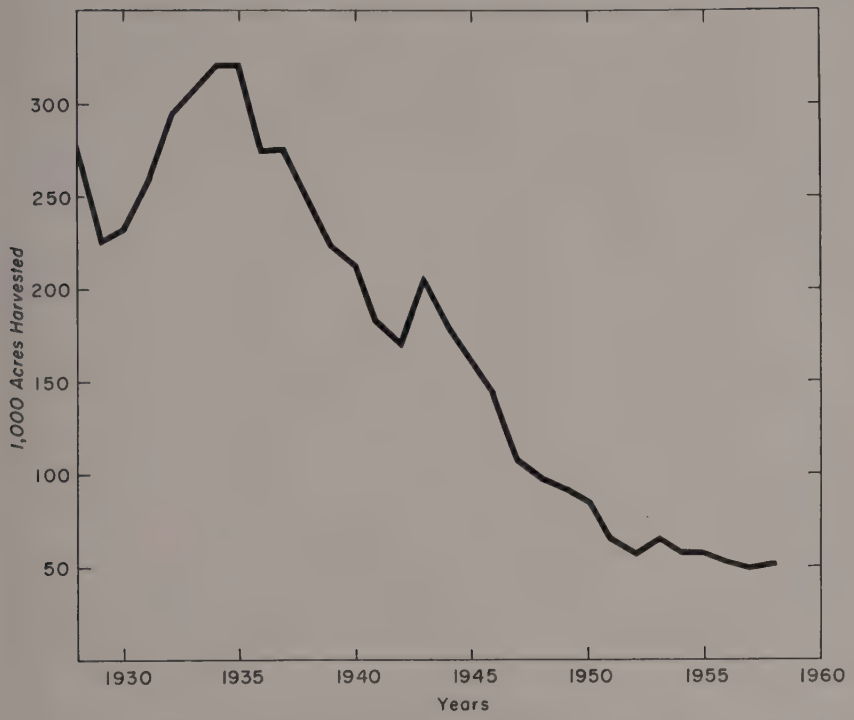

Fig. 1. Changes in acres of potatoes harvested in Michigan, 1934-1958.

were calculated for corn, wheat, field beans, sugar beets, and potatoes, five important cash crops grown in Michigan. During this period, the acreage of corn was increased by 21 percent and the wheat acreage by 49 percent. The acreage of field beans was reduced by 22 percent, sugar beets by 32 percent and potatoes by 76 percent (Table 1).

During the same 20-year period, average yields per acre for the five major crops have increased from 35 percent for field beans to 107 for potatoes (Table 1). Increases in the yield of wheat, sugar beets and corn ranged from 40 to 56 percent. Improved varieties, application of improved production practices, greater use of fertilizer and better methods of harvesting and handling have been major reasons for these yield increases. For potatoes, irrigation has been a factor in the increase. It was estimated that in 1958, about 17 percent of the potato acreage harvested in the state was irrigated.

The tendency for individual farmers to discontinue producing potatoes for their own household use has been a factor in the reduction in the total acres grown. Other important factors influencing the change in the total potato acreage are (1) a reduction in the quantities of potatoes consumed per capita (130 pounds in 1935-39 to 101 pounds in 1959), (2) changes in the price relationships between different crops grown, (3) changes in mechanization and application of new technology in the production of different crops, (4) trends toward greater specialization in the production of crops, and (5) competition from other potato growing areas.

Production of potatoes has been reduced more for Michigan than the United States as a whole. For the period 1928-37, Michigan produced 8.4 percent of the acreage and 11.7 percent of the total hundred weight of potatoes. For the later 10-year period, 1948-57, Michigan farmers grew 4.7 percent of the acreage and 3.8 percent of the total production.

TABLE 1—Changes in acres harvested and yield, by 10-year periods, for potatoes and other Michigan cash crops, 1928-57 and 1948-57(a)

	Acres harvested			Yield per acre			
	1928-37	1948-57	Change	Unit	1928-37	1948-57	Change
	Acres	Acres	Percent				Percent
Corn	1,468,000	1,782,000	+21.4	bu.	29.2	45.7	+ 56
Wheat	804,500	1,202,000	+49.4	bu.	19.9	27.6	+ 40
Field beans	566,000	441,000	−22.0	cwt.	6.9	9.3	+ 35
Sugar beets	93,600	63,600	−32.1	ton	7.7	11.3	+ 47
Potatoes	279,600	68,300	−75.7	cwt.	55.0	114.0	+107

(a) Data from Michigan Agricultural Statistics annual reports, Michigan Cooperative Crop Reporting Service, Lansing, Michigan.

County and Area Changes

Crop acreage and yield data have been available for individual counties on an annual basis only since 1943 (from the Michigan Crop and Livestock Reporting Service). In 1958, 42 percent of the total acreage of potatoes in Michigan was grown in six counties in which 1,400 or more acres were harvested per county. They are Houghton, Antrim, Presque Isle, Montcalm, Lapeer and Bay. In 1943, less than 20 percent of the acreage was grown in these six counties. Changes in yield per acre for these six counties and the state have been calculated for two five-year periods: 1944-48 and 1954-58. For the state

as a whole, the yield of potatoes was more than doubled from the average of the first five-year period, 1944-48, to the most recent five-year period, 1954-58. For the six counties, yields have increased from 32 percent to 152 percent, the greatest increase taking place in Lapeer County (Table 2).

TABLE 2—Changes in yield of potatoes for Michigan and selected counties(a) yield averages and changes for periods, 1944-48 and 1954-58(b)

State and counties	Yield per acre		Increase per acre		Acres harvested	
	1944-48	1954-58			1943	1958
	Cwt.	Cwt.	Cwt.	Percent	Acres	Acres
State	71	149	78	110	213,000	52,500
Houghton	89	163	74	83	6,000	2,700
Antrim	93	135	42	45	3,500	1,400
Presque Isle	95	125	30	32	5,200	4,060
Montcalm	99	207	108	109	13,000	6,600
Lapeer	63	159	96	152	5,700	1,500
Bay	65	123	58	89	8,000	6,000

(a) Includes counties in which 1,400 or more acres of potatoes were grown in 1958. Forty-two percent of the total acreage of potatoes were grown in these 6 counties. Fifteen years ago, in 1943, less than 20 percent of the acreage was grown in these counties.
(b) Data from Michigan Cooperative Crop Reporting Service, Lansing, Michigan.

The acreage of potatoes harvested in Michigan during the 15-year period, 1943 to 1958, was reduced by 75 percent. When the state was divided into four major areas; the Upper Peninsula, the Northern, the Central, and the Southern areas the reduction in acreage was greatest for the Southern area (88 percent) and lowest for the Upper Peninsula, 67 percent (Table 3). Reductions for the northern and central areas were 72 and 76 percent, respectively. The area

TABLE 3—Acreages of potatoes grown during 1943 and 1958 and percentage change in Michigan and four areas of the state

State and area	1943	1958	Reduction	
	Acres	Acres	Acres	Percent
State	213,000	52,500	160,500	75
Upper Peninsula	24,800	8,200	16,600	67
Northern	46,000	12,900	33,100	72
Central	85,000	20,400	64,600	76
Southern	57,200	11,000	46,200	88

designated as the Central produces 40 percent of the potatoes in the state. This includes three of the six potato counties in which 1,400 or more acres were harvested in 1958.

Potato Production Practices

During 1957 and 1958, information was obtained on the acres of potatoes grown per farm, quantities of fertilizer used, number of times the crop was sprayed, and on major inputs of labor, machinery, fuel and oil, seed, and other materials in the production and harvesting of the potato crop. Bay, Monroe, Montcalm and Presque Isle Counties have been selected to show the production practices used in four major potato growing areas in Michigan. Unfortunately, the study did not include any counties in the Upper Peninsula.

Bay County

Bay is largely an early-harvest potato area in which high value crops are important. On 17 farms studied, about 20 percent of the cropland acreage was planted to potatoes, an equal acreage planted to sugar beets, nearly 30 percent planted to field beans and the balance of the acreage in wheat, corn, oats and other feed crops. About one-half of the potato acreage on the 17 farms was produced on land which had been in potatoes the previous year. The other half followed sugar beets, corn, sod crops and field beans. Irrigation is used to only a a limited extent in the production of potatoes. Most of the farmers had no livestock.

Nine of the farmers in the Bay County study grew less than 30 acres per farm. The average was 17 acres. These growers used an average of 25 bushels of seed and 862 pounds of fertilizer per acre. A cover crop was plowed down on 42 percent of the acreage. They cultivated their potatoes 4.3 times and sprayed an average of 4.2 times during the season. An average of 11.6 hours of man labor, 7.4 hours of tractor time and 1.6 truck miles were used in growing an acre of potatoes.

The eight farmers who were growing 30 to 59 acres of potatoes planted about the same quantity of seed but used 200 more pounds of fertilizer per acre than the growers with less than 30 acres of potatoes (Table 4). Ninety-two percent of the potato acreage followed a green-manure crop. There was very little difference in the hours of manual labor, tractor time, or truck miles per acre for the two groups of farms.

TABLE 4—Seed, fertilizer, labor, power, truck, machinery and other imputs in growing one acre of potatoes in Bay county, 1957-58

	Under 30 acres potatoes	30-59 acres potatoes
Number of farms	9	8
Acres potatoes per farm	17	48
Yield per acre, bu(*a*)	255	314
Inputs per acre:		
Seed, bu.	25	24
Fertilizer, lbs.	862	1,073
Cover crop, percent acres	42	92
Spraying, times per acre	4.2	4.8
Labor, hours	11.6	12.0
Tractor, hours	7.4	6.1
Truck, miles	1.6	1.3

(*a*) Marketable potatoes.

Monroe County

Monroe is a high-land value county in which potatoes compete with tomatoes and other canning crops, as well as with corn, soybeans and other high-value crops. The potato acreage in this county was reduced by 70 percent during the 15-year period 1943 to 1958. This compares with reductions of 25 percent in Bay and Presque Isle Counties and 50 percent in Montcalm County. Irrigation is an important practice on many of the farms on which potatoes and truck crops are produced. Eighteen farms were included in the study. Potatoes were grown on only 13 percent of the crop acres. Tomatoes and other vegetable crops made up nearly 25 percent, corn and soybeans together nearly 30 percent, and wheat and oats 22 percent of the cropland acreage in Monroe County.

Inputs of seed and fertilizer, and the use of cover crops in growing 1 acre of non-irrigated potatoes were essentially the same for the farms with under 30 acres and the farms with 30-59 acres of potatoes (Table 5). The application of fertilizer was considerably higher than for Bay County. The Monroe County growers also sprayed their potatoes an average of four more times per acre. Less hours of labor and tractor time were recorded per acre for the larger plantings.

The farmers who irrigated their potatoes used from 5 to 8 more bushels of seed and from 300 to 900 more pounds of fertilizer per acre than did the non-irrigators (Table 5). The growers producing 90 or

TABLE 5—Seed, fertilizer, labor, power, truck, machinery and other inputs in growing one acre of potatoes in Monroe county, 1957-58

	Non-irrigated		Irrigated	
	Under 30 acres	30-59 acres	60-89 acres	90 and over acres
Number of farms	6	5	4	3
Acres per farm	18	43	67	133
Yield per acre, bu(*a*)	341	314(*b*)	313(*b*)	380
Inputs per acre:				
Seed, bu	23	21	28	29
Fertilizer, lbs	1,290	1,238	1,593	2,120
Cover crop, percent acres	32	29	100	100
Spraying, times per acre	8.2	7.5	9.0	12.0
Labor, hours	10.0	8.4	9.7	9.4
Tractor, hours	8.2	6.1	6.4	6.4
Truck, miles	—	—	—	1.6

(*a*) Marketable potatoes.
(*b*) Unfavorable weather in 1958 greatly reduced yields.

more acres of irrigated potatoes used the largest quantities of seed and fertilizer per acre. Cover crops were plowed down for all of the irrigated potatoes.

Fig. 2. Spraying potatoes to control insects and diseases is an important practice resulting in increased yield and quality of potatoes. Yields are greatly reduced when growers neglect this practice.

Montcalm-Kent Counties

In 1958, growers in Montcalm County harvested 6,600 acres of potatoes, or more than in any other county in the state. This county, as well as parts of Kent and Newaygo, are potato areas in which major changes have been made in production and irrigation practices. A considerable number of growers harvest 50 or more acres of potatoes with a very high percent of these using irrigation. Potatoes were the most important cash crop on the 56 farms studied. They accounted for nearly 20 percent of the cropland on the farms with less than 60 acres of potatoes. Pickles, wheat and field beans together accounted for 20 percent. Nearly half of the cropland was used in growing feed crops for dairy cattle.

On farms with more than 60 acres of potatoes, this crop accounted for about 40 percent of the cropland. Pickles, wheat and field beans together, accounted for nearly this same percentage. Only 10 percent of the cropland was in feed crops since there was very little livestock produced on the farms with 60 or more acres of potatoes.

In the Montcalm-Kent area, farmers who were growing less than 30 acres of potatoes and using irrigation planted about the same quantity of seed but applied about 500 pounds more fertilizer and 6 tons less barnyard manure per acre than did the non-irrigators (Table 6). There was very little difference in green manure and spraying practices. Irrigators used 2 hours more of man labor and tractor use than did the non-irrigators.

For the farmers growing 30 to 59 acres of potatoes, the irrigators planted 8 bushels more seed and used 560 pounds more fertilizer per acre than did non-irrigators. The farmers who irrigated sprayed their potatoes three more times and used nearly 4 more hours of man labor per acre in growing potatoes than did non-irrigators.

The growers who irrigated and produced more than 60 acres of potatoes per farm applied 100 pounds more fertilizer and used 4 hours less man labor per acre. In other respects, they used about the same inputs per acre as growers who irrigated and produced 30 to 59 acres.

Presque Isle County

Presque Isle is the third largest potato growing county in the state, harvesting about 4,000 acres annually in recent years. In 1954, growers in Presque Isle and Montcalm Counties averaged about 9 acres of potatoes per farm. This was the largest average of any of the counties in the state and compares with an average of about 2½ acres for

TABLE 6—Seed, fertilizer, labor, power, truck, machinery and other inputs in growing one acre of potatoes in Montcalm-Kent areas, 1957-58

	Under 30 acres potatoes		30-59 acres potatoes		60-89 acres potatoes	90 and over acres potatoes
	Non-irrigated	Irrigated	Non-irrigated	Irrigated	Irrigated	Irrigated
Number of farms.....	4	6	13	12	10	11
Acres, potatoes per farm.	25	24	41	44	72	133
Yield per acre, bu(*a*)....	271	356	274	394	413	372
Inputs per acre:						
Growing:						
Seed, bu.....	28	29	26	34	36	35
Fertilizer, lbs.....	660	1,176	761	1,320	1,434	1,410
Barnyard manure, tons	9	3	3	1	—	—
Cover crop, % acres...	36	58	96	100	100	100
Spraying, times per acre.....	9.5	10.1	7.5	10.6	13.6	12.6
Labor, hours.....	11.9	13.7	12.5	16.2	12.1	12.7
Tractor, hours.....	7.5	9.4	8.2	8.5	7.6	7.2
Truck miles.....	1.3	2.1	1.7	1.8	2.3	2.2

(*a*) Marketable potatoes.

Fig. 3. Increased specialization is resulting in more acres of potatoes grown per farm and generally in higher yields per acre. The grower who produces less than 10 acres of potatoes finds it difficult to make an economical use of improved machinery and practices.

other farms in the state. Presque Isle has been largely a diversified area in which most farmers produced both milk and potatoes, as well as some wheat and barley. Potatoes and wheat are the two most important cash crops, each making up about 15 percent of the cropland. More than one-half of the cropland is in hay and pasture. The recent location of a potato processing plant in the county will undoubtedly influence potato production.

Most growers in Presque Isle and other Northern counties plant less than 30 acres per farm. In recent years, several growers have produced 30-59 acres and a few 60 or more. Irrigation has been used on a few farms. The 35 farmers who grew less than 30 acres used about the same quantities of seed, fertilizer and barnyard manure per acre as those who grew 30-59 acres (Table 7). Growers of 30-59 acres of potatoes sprayed their potatoes two more times during the season and used less hours of labor and tractor than did the other growers. Yields were 65 bushels per acre greater for farmers with larger acreages.

In both 1949 and 1954[3], 4 percent of the growers in Michigan produced almost half of the acreage of potatoes. These 4 percent represented those growing 10 or more acres per farm. The other 96

[3]U. S. Census of Agriculture Report for Michigan.

TABLE 7—Seed, fertilizer, labor, tractor, truck, machinery and other inputs in growing one acre of potatoes in Presque Isle county, 1957-58

	Under 30 acres potatoes	30-59 acres potatoes
Number of farms	35	10
Acres, potatoes per farm	12	38
Yield per acre, bu(*a*)	233	298
Inputs per acre:		
Seed, bu.	22	23
Fertilizer, lbs.	577	661
Barnyard manure, tons	7	6
Cover crop, percent acres	37	69
Spraying, times per acre	5.4	7.3
Labor, hours	15.7	11.4
Tractor, hours	8.8	6.4
Truck miles	—	1.6

(*a*) Marketable potatoes.

percent of the growers produced the other 50 percent of the acres. This situation probably has changed since 1954.

An Economic Appraisal of Alternative Potato Plans

Potatoes yielded from less than 200 to more than 400 bushels per acre on farms where no irrigation was used. The variation in yields was even greater for irrigated farms. The acreage of potatoes grown per farm ranged from less than 10 acres to more than 200. Some of the farmers specialized in production of potatoes while others grew them as a minor enterprise. There were great differences in the use of recommended production practices, and fertilizer, seed and other inputs per acre of potatoes. These variations resulted in marked differences in yields, expenses and returns.

Montcalm-Kent Area Alternatives

Farms from two of the production areas studied were selected to test out the effect of using different combinations of production practices and combination of crop and livestock enterprises. The first farm studied was in Montcalm County on which 40 acres of non-irrigated potatoes were grown. Two alternative situations were budgeted for this farm: one in which average production practices were used in growing the potatoes and the other a full use of recommended practices, including fertilizer, seed, spray material and other inputs.

An average situation is one in which a farmer uses his own seed for most of the acreage, purchasing new seed occasionally. The average rate of planting would be 21 bushels per acre, spacing in the row 14 inches, and only part of the potatoes would follow a cover crop. About 100 pounds of fertilizer would be used in growing this cover crop. About 600 pounds of fertilizer would be applied at planting time, potatoes would be sprayed about seven times, and the yields of marketable potatoes would be 225 bushels per acre.

When improved practices were used, most of the acreage would be planted to seed from certified stock, spacing in rows somewhat closer, and about 8 more bushels of potatoes planted per acre. One hundred pounds more fertilizer would be applied on the cover crop and about 400 pounds more on the potatoes. About 66 pounds of nitrogen side-dressing would also be applied. The actual quantity and analysis of fertilizer used would be determined by soil and plant tissue testing. Potatoes would be sprayed about 12 times and they would yield 327

bushels, or about 100 bushels more than those grown under average practices (Table 8). These differences are based on actual farm records which showed the inputs and yields for growers using different practices.

The second set of alternatives tested out for the farm with 40 acres of potatoes involved using irrigation equipment with the average and improved practices. Here again, the farmer would make greater use of seed from certified stock and plant the potatoes closer in the row. They would plant about 8 more bushels per acre, apply 80 more pounds of fertilizer to the cover crop, grow and plow down cover crops for most of the acreage to be put in potatoes and apply about 700 pounds more fertilizer.

Twice as much nitrogen would be used in side-dressing the potatoes. Potatoes would be sprayed about 12 times, or five more times than those grown under average conditions. Irrigation would be more timely and at least one more application during the season would be made with nearly twice as many inches of water applied. Yields would be 200 bushels more when recommended rather than average irrigation practices were used.

Changing from average to recommended practices under non-irrigated conditions would add more than $3,670 to value of sales and about $3,000 to expenses. These changes would increase net income by about $670. If a farmer using average practices in growing 40 acres

TABLE 8—Production practices used in growing 40 acres of non-irrigated and irrigated potatoes in Montcalm county, 1957-58

	Non-irrigated		Irrigated	
	Average practices	Recommended practices	Average practices	Recommended practices
Spacing in row	14"	9"-11"	12"	9"
Bushels seed per acre	21	29	25	33
Fertilizer per acre:				
Cover crop, lbs.	100	200	120	200
Planting time, lbs.	600	1,000(*a*)	800	1,500(*a*)
N side dressing, lbs.	—	66(*a*)	33	66(*a*)
Number times sprayed	7	12	7	12
Number of times irrigated	—	—	2.0	2.9
Inches of water applied	—	—	2.2	3.6
Yield, bushels per acre marketable potatoes	225	327	268	477

(*a*) These quantities will vary depending on soil and tissue tests.

of potatoes invested in equipment for irrigating potatoes without making improvements in his cultural practices and increasing the inputs of seed and fertilizer, he could expect to reduce his net income. A 45-bushel estimated increase in yields resulting from irrigation would not begin to pay for the additional cost of depreciation and repairs on the irrigation equipment, and the fuel, oil, and labor needed to carry out an irrigation program.

The investment and use of irrigation would result in a net income of about $5,662 which is a $2,500 gain over no irrigation. These cal-

TABLE 9—Estimated receipts, expenses and net income resulting from using average and recommended production practices and no irrigation and irrigation in producing 40 acres of potatoes in Montcalm county, 1957-58

	Non-irrigated		Irrigated	
	Average practices	Recommended practices	Average practices	Recommended practices
Bushels	225	327	268	477
	Dollars	Dollars	Dollars	Dollars
Value of sales				
Potatoes ($0.90 per bu.)	8,100	11,772	9,648	17,172
Other income	700	700	700	700
Total	8,800	12,472	10,348	17,872
Expenses(a)				
Fertilizer	912	1,928	1,252	2,808
Seed potatoes	1,220	1,740	1,480	1,960
Rye—cover crop	120	160	120	160
Spray material	272	880	288	880
Dep. and repairs and int.				
Grow and harvest	1,068	1,142	1,068	1,142
Irrigation	—	—	631	631
Fuel and oil				
Grow and harvest	230	252	230	252
Irrigation	—	—	130	180
Hired labor				
Grow and harvest	1,500	1,990	1,662	2,527
Irrigation	—	—	300	300
Taxes and insurance	220	260	220	260
Custom hire	200	200	200	200
Miscellaneous	560	750	650	910
Total Expenses	6,302	9,302	8,231	12,210
Net Income	2,498	3,170	2,117	5,662

(a) Expenses for a whole farm situation. Includes expenses in planting and growing cover crops.

culations are based on using recommended practices. Many farmers fail to increase net income when they irrigate because they do not make appropriate changes in other practices associated with growing potatoes.

Presque Isle County Alternatives

A second farm studied was typical of growers in Presque Isle County who were growing less than 30 acres per farm. The farm situation budgeted had 156 acres of cropland, 18 acres of potatoes and 17 Holstein cows averaging 8,500 pounds of milk sold annually. It was assumed that average production practices were used in growing the 18 acres of potatoes yielding 300 bushels or 180 cwt. per acre. Other crops grown included 28 acres of oats, 20 of wheat, nine of silage corn, and 78 of alfalfa-brome grass for hay and pasture. With the exception of the need to purchase a small amount of grain, sufficient feed would be produced to feed the 17 cows and the necessary replacement heifers.

With the following prices projected into the future: potatoes, $1.50 per cwt.; wheat, $1.85 per bushel; and 3.5 test milk at $3.80 net per cwt. for milk, receipts would total slightly more than $12,000, expenses slightly more than $I0,000, leaving a net income of $2,000 or slightly more if the benchmark (present plan) was continued in the future (Table 10).

The first alternative tested (Plan 2) consisted of continuing operation of the 156 acres and keeping the 17 cows, but expanding potato production to 52 acres, or one-third of the cropland on the farm. It was assumed that the cropland on the farm was suitable for a rotation in which a third of the land would be in potatoes, approximately a sixth in small grain, a sixth in green manure crops and the balance in feed crops for the dairy herd.

It would be necessary to purchase about $1,200 worth of feed under this situation since more of the land would be devoted to potatoes. With the additional potatoes, it would be necessary to spend about $600 more for seasonal help, mostly during the potato harvest season. Cost of picking potatoes was charged at 14 cents per bushel. This change in organization would add $8,792 to receipts and $7,757 to expenses, or a net gain of somewhat more than $1,000.

This appears to be a good alternative for a farmer who has somewhat limited acreages of cropland and some additional family help becoming available. With the additional acreage of potatoes, it would

be necessary to invest approximately $6,300 more in equipment for producing and harvesting. An extra tractor also would be needed.

The next set of alternatives included purchase of 60 more acres of cropland of about the same quality as that already farmed. This would make a total of 216 acres. Five changes in acreages and yields of potatoes and in the number of production of dairy cows were studied. The first alternative in this situation was to increase the potato acre-

TABLE 10—Estimated receipts, expenses and net income in two alternative cropping plans on farms with 156 acres cropland and potato-dairy enterprises, Presque Isle county

	PLAN 1 Continue present cropping plan	PLAN 2 Increase acres of potatoes to 52
Number of cows	17	17
Acres of potatoes	18	52
	Dollars	Dollars
Change in investment(*a*)	—	+6,260
Receipts		
Milk	5,490	5,490
Cattle and calves	510	510
Potatoes	4,860	14,040
Other crops	1,424	1,036
Total	12,284	21,076
Expenses		
Fertilizer, lime and seed	3,092	5,845
Fuel, oil and custom work	1,105	1,490
Depreciation, operation and maintenance		
Forage and feed equipment	763	763
Power and field equipment	1,477	2,510
Buildings and equipment	1,292	1,292
Spray material	180	520
Hired labor, seasonal	400	1,000
Harvesting potatoes	756	2,184
Miscellaneous dairy	425	425
Electricity, taxes and insurance	540	540
Feed	220	1,250
Interest on additional investment	—	188
Total	10,250	18,007
Net Income	2,034	3,069
Change in Net Income	—	+1,035

(*a*) Added investment in larger tractor, sprayer and other equipment in growing the larger acreage of potatoes.

age to 40 and continue to milk the 17 cows. For Plan 3, it was estimated that buying more land and additional equipment for growing more potatoes would add $12,300 to investment. This alternative, involving purchasing more land and increasing potato acreage to 40, would add no more to net income than Plan 2, which suggested an increase in potato acreage to 52 on the present acreage (Tables 10 and 11).

The second alternative tested involved determining the effect of discontinuing the potato enterprise, but increasing dairy cows milked to 35 and assuming that the present milk sales per cow, 8,500 pounds, would be the same for the 35 cows. It was assumed that the same quantity of labor would be hired for both situations. Gross sales would be increased by about $1,100 over the original situation but expenses would increase by about $1,400. This would result in a $254 reduction in net income (Plan 4, Table 11). This indicates that when milk sales average only 8,500 pounds or less per cow that dairy cows do not compete well with growing potatoes which yield 300 bushels per acre.

The next alternative studied was to determine the effect on net income of substituting 35 cows producing 10,000 pounds of milk for sale for the present ones producing 8,500 pounds. Gross sales would be increased by about $2,100 while expenses would increase about $1,100 over the 8,500-pound producing cows. The net effect would be to add $861 over the original 156-acre situation (Plan 5, Table 11). This would be slightly less profitable than the alternative of increasing potato acreage to 40 and keeping the 17 cows producing 8,500 pounds of milk, or the plan to increase potato acreage to 52, keeping the 17 cows and maintaining the 156 acres of cropland. Two additional cows would probably have increased net income to the same level as the other two alternatives.

Two additional alternatives tested for the 216 acres of cropland were to eliminate the dairy cows and increase potato acreage to 60. In Plan 6, the changes in investments, receipts and expenses were calculated for the present level of practices which resulted in a yield of 300 bushels of potatoes per acre. In Plan 7, it was assumed that a greater application of improved practices, including the purchase of better potatoes, greater use of fertilizer, more attention to spraying, and timeliness in various operations would add about 25 percent to yields. The resulting yield would be 375 bushels per acre, a feasible goal. Some of the more successful growers in the Presque Isle area

TABLE 11—Estimated receipts, expenses and net income in four alternative crop and livestock plans with 60 acres additional cropland, Presque Isle county

	PLAN 3 Increase acres of potatoes to 40	PLAN 4 Increase cows to 35, discontinue potatoes, average cows	PLAN 5 Increase cows to 35, discontinue potatoes, better cows	PLAN 6 Discontinue cows, grow 60 acres of potatoes, Average practices	PLAN 7 Discontinue cows, grow 60 acres of potatoes, improved practices
Number of cows	11	35	35	—	—
Pounds milk sold per cow	8,500	8,500	10,000	—	—
	Dollars	Dollars	Dollars	Dollars	Dollars
Change in investment(*a*)	+12,300	+24,500	+28,000	+4,400	+6,000
Receipts					
Milk	5,490	11,305	13,300	—	—
Cattle and calves	510	1,050	1,200	—	—
Potatoes	10,800	—	—	16,200	20,250
Other crops	2,317	1,036	1,036	3,438	3,438
Total	19,117	13,391	15,536	19,638	23,688
Expenses					
Fertilizer, lime and seed	5,679	2,628	2,628	6,830	8,117
Fuel, oil and custom work	1,403	970	970	1,386	1,486
Depreciation, operation and maintenance					
Forage and feed equip.	763	1,018	1,018	200	200
Power and field equip.	2,312	1,905	1,905	2,651	2,651
Buildings and equip.	1,292	1,930	1,930	1,040	1,040
Spray material	400	—	—	600	1,200
Hired labor, seasonal	800	400	400	1,000	1,200
—harvesting potatoes	1,680	—	—	2,520	3,150
Miscellaneous dairy	425	855	1,200(*b*)	—	—
Elect., taxes and insurance	580	625	680	680	680
Feed	170	493	945	—	—
Interest on add'l investment	488	787	965	220	300
Total	15,992	11,611	12,641	17,127	20,024
Net Income	3,125	1,780	2,895	2,511	3,664
Change in Net Income(*c*)	+1,091	− 254	+ 861	+ 477	+1,630

(*a*) Added investment for 60 acres cropland, more and better cows, and larger tractor and other equipment needed in growing the larger acreage of potatoes.

(*b*) Includes depreciation for higher producing cows purchased in addition to D.H.I.A. breeding, veterinary and other dairy expenses.

(*c*) Change from present or benchmark plan.

are producing 400 bushels per acre by using recommended production practices. The first of these alternatives, namely discontinuing the dairy enterprise, increasing potatoes to 60 acres with yields at 300 bushels, would add $477 to net income. When greater use is made of improved practices and better seed as well as applying more fertilizer, gross sales would be increased by about $4,000; expenses by about $2,900, which would leave a net gain of $1,200 over the first situation. This would be a net income of $3,664, compared to $2,034 for the benchmark situation (Tables 10 and 11). This appears to be the most profitable alternative for this farm. A dairy herd of 40 or more cows, producing at least 10,000 pounds of milk, would bring about the same net income. In adding a dairy enterprise, investments would be increased a good deal more than for the potato enterprise expansion.

The situations tested for Montcalm and Presque Isle Counties illustrate only a few of the alternatives which potato growers might consider in improving net income. Most growers will probably increase net income more first by using improved practices, better seed potatoes, more fertilizer, a more timely spray schedule and following other recommended practices, than by increasing acreage or making other changes. Many farmers who are now producing only a few acres of potatoes will need to increase the acreage if they expect to make economical use of improved machinery and production practices.

Fig. 4. The future of the potato enterprise in Michigan depends on how well growers make use of improved practices and produce the quality and varieties of potatoes acceptable to consumers and processors.

EVALUATION OF PEA INTRODUCTIONS FOR RESISTANCE TO APHANOMYCES AND FUSARIUM ROOT ROTS[1]

By JOHN L. LOCKWOOD and J. C. BALLARD

DEPARTMENT OF BOTANY AND PLANT PATHOLOGY AND DEPARTMENT OF HORTICULTURE

SUMMARY

EIGHT HUNDRED AND FIVE accessions of *Pisum sativum* L. were evaluated in greenhouse tests for resistance to an isolate of *Aphanomyces euteiches* Drechs. Based on a disease scale from 0-8 with 0 indicating healthy plants and 8, dead plants, only 18 introductions were rated less than 5. None was rated 0 or 1. Seven hundred and ninety three accessions were evaluated for resistance to an isolate of *Fusarium solani* f. *pisi* (F. R. Jones) Snyder & Hansen. Based on a disease scale from 0-9, 69 introductions were rated 1-3. No immune accessions were found. In spite of heterogeneity of individual accessions with respect to seed type and other characteristics, no individuals were found with higher levels of resistance than that of the most resistant introductions.

INTRODUCTION

Root rots, year in and year out, are the limiting factor in pea production in Michigan as well as in other pea growing states (King et al., 1957; King and Hogland, 1959; Lockwood et al., 1957; Schroeder et al., 1955; and Walker and Hare, 1943). In Michigan the disease is found in nearly all fields and causes severe losses in some years. There appear to be two important fungi involved in the etiology of pea root rot, *Aphanomyces euteiches* Drechs., and *Fusarium solani* f. *pisi* (F. R. Jones) Snyder & Hansen. In an effort to find sources of resistance so that a program of breeding could be undertaken to develop varieties

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resistant to root rot, introductions of *Pisum sativum* L. supplied by the Regional Plant Introduction Station at Ames, Iowa were tested in the greenhouse to determine their resistance to an isolate of each of these two root rot fungi. There apparently are no commercial varieties resistant to either pathogen, although breeding programs are in progress in New York (Schroeder et al, 1955) and Minnesota (King et al, 1957 and 1959) as well as in Michigan.

MATERIALS AND METHODS

Twenty-seed lots of each accession were soaked for 15 minutes in 0.5 percent sodium hypochlorite (10 percent Chlorox) to kill surface fungi, then rinsed with tap water. Untreated seed frequently carried superficial fungi such as *Rhizoctonia solani* Kühn capable of growing rapidly through the flats and blighting the test seedlings. Some accessions with "hard" seeds were mechanically scarified before treatment to obtain uniform germination.

Seed for the Aphanomyces root rot tests was planted in rows 2 cm deep in washed silica sand in metal pans with dimensions 20 x 22 x 4 in. (Lockwood and Ballard, 1958). Five pea introductions plus a susceptible commercial variety, usually Miragreen, were included in each pan. One row was used for each variety. Pans were placed on a greenhouse bench at 22-26°C until seedlings were ½-1 in. high (4-6 days after planting) when they were inoculated. Seedlings were inoculated with zoospore suspensions of *A. euteiches* adjusted to a concentration of $1x10^5$ per ml; 10 ml of this suspension was pipetted uniformly along each row. Sand was saturated with tap water following inoculation. About 12 hours before inoculation pans were placed in temperature tanks (Lockwood and Ballard, 1958) at 24° where they remained until root rot data were taken.

Seed for the Fusarium root rot tests was planted 5 cm deep in sand in wooden flats 20 x 14 x 3¾ in. or metal pans such as those used for the Aphanomyces tests. Wooden flats were used only for the first screening and were placed in a greenhouse with an air temperature of approximately 28°. Six accessions plus 2 rows of a susceptible commercial variety, usually Early Perfection, were included in each flat. Accessions tested a second or third time were grown in sand in metal pans. Pans containing the sand and seeds were placed in a water bath at 28°immediately after planting. Seedlings in both types of containers were inoculated 4 days after planting. Ten ml of a conidial suspension

adjusted to a concentration of 2.5×10^5 per ml was pipetted uniformly along each row. After inoculation sand was saturated with water.

The respective cultures used, *A. euteiches* isolate 50, and *F. solani* f. *pisi* isolate 48 were derived from single zoospore or single conidial cultures isolated from Michigan. These isolates were highly pathogenic to pea seedlings. Both were maintained on potato-dextrose agar (Lockwood, J. L., and J. C. Ballard, 1959). *A. euteiches* was induced to form zoospores by growing cultures for 5 days in maltose-peptone broth in 250 ml flasks, replacing the medium with 40 ml of tap water for 2 hours, then with 40 ml of distilled water for 8-10 hours (Llanos, 1959; and Lockwood and Ballard 1959). *F. solani* f. *pisi* conidia were obtained from 5-7 day-old agar slants.

Disease in tops of plants, epicotyls, and roots was estimated 8-12 days after inoculation in the case of Aphanomyces root rot; the most severely infected plants usually were dead by this time. Tops of plants with only the lower one or two leaves wilted were rated 1, completely wilted tops were rated 3, and intermediate stages were rated 2. Water-soaked epicotyls were rated 1, and collapsed epicotyls, 2. Slightly decayed roots were rated 1, completely decayed roots were rated 3, and intermediates were rated 2. Healthy parts were rated 0. Fusarium root rot was rated 3 weeks after inoculation. The rating system used for Fusarium root rot was similar to that used for Aphanomyces root rot except that epicotyl-hypocotyl area was rated 0.3, with 0 indicating no disease; 1, superficial brown flecks; 2, moderate browning and decay; and 3, complete browning and girdling. The total of the 3 ratings for each accession constituted the disease index, maximum being 8 for Aphanomyces root rot and 9 for Fusarium root rot.

The susceptible control in the Fusarium root rot test usually had a disease index less than 9, and severity of disease varied from test to test. Therefore all Fusarium disease indices were adjusted in proportion to disease in the control, e.g., if Early Perfection was rated 6.0, an accession rated 2.0 would become 3.0.

A detailed account of some variable factors affecting the Aphanomyces root rot test has been published (Lockwood and Ballard, 1959).

RESULTS

A total of 817 accessions of *P. sativum* was received from the Regional Plant Introduction Station at Ames, Iowa. Of these, 805 were evaluated for resistance to Aphanomyces root rot, and 793 were evalu-

ated for resistance to Fusarium root rot. Difficulty in increasing the seed of a few small samples precluded the testing of those samples. Accessions with the following P.I. numbers were evaluated for resistance to Fusarium root rot: 116843-4, 116944, 117264, 121976-7, 123246, 123556, 124478-80, 124595, 125672-3, 134271, 135920, 137118, 137120, 138945, 140165, 140295-8, 141351, 141966, 142441-2, 142774-7, 143483-4, 143486, 162567-8, 162691-3, 162909-10, 163125-9, 163131, 163133-4, 164147-8, 164182, 164285, 164304, 164346, 164396, 164417, 164426, 164523, 164548, 164568, 164612, 164614, 164669, 164690, 164758, 164766, 164779, 164787, 164836-8, 164853, 164971-2, 165564, 165577, 165897, 165949, 165965, 166051, 166082, 166084, 166117, 166129, 166142, 166159, 166187-8, 167204-5, 167250-1, 167253, 167273, 167363, 169600-10, 170669, 171810-16, 172338-42, 173052, 173055-9, 173778-80, 173840, 173929-30, 174319-22, 174917-27, 175226-33, 175877-8, 176721, 177053-6, 177521, 179019, 179448-61, 179721-3, 179969-72, 180326-9, 180470-2, 180692-704, 180867-8, 181799-801, 181958, 182984-5, 183068, 183140-2, 183334-6, 183413-4, 183466-7, 183713-4, 183910, 183944-6, 184128-31, 184784, 185183, 188698, 189168, 189171, 193578-91, 193835-49, 194006-8, 194338-50, 195017-27, 195404-5, 195628-31, 196009-33, 196876-7, 197044, 197449-54, 197987-8, 197990, 198072-4, 198735, 200755, 201390-1, 201497, 202049, 203064-9, 203944, 204305-7, 204667, 204724, 205214-6, 206006, 206781-875, 206988-9, 207508, 209506-7, 210558-79, 210581-624, 210626-35, 210637, 210640-674, 210676-85, 212028-31, 212112, 212915-8, 214064, 214344, 215766, 219705-6, 220174-5, 220189, 220673, 221697, 222069-71, 222117, 222534, 223284-5, 223526-7, 234203, 240513-9, 241593, 244054-5, 244088-106, 244108-45, 244147-52, 244154-64, 244166-82, 244184-91, 244193-8, 244200-9, 244211-5, 244217, 244220, 244223-34, 244236-41, 244243-56, 244258-64, 244266-72. All of the preceding accessions except P.I. 244189 were evaluated for resistance to Aphanomyces root rot. In addition accessions with the following P.I. numbers were evaluated for resistance to Aphanomyces root rot: 120617, 210625, 210636, 210675, 242027, 244153, 244199, 244210, 244216, 244222, 244235, 244242, 244257.

In the first screening for resistance to Aphanomyces root rot 708 accessions had disease indices of 7-8, and 79 disease indices of 5-6, whereas only 18 introductions were rated 2-4, and none, 0 or 1. Of the 79 accessions rated 5-6,only 9 were rated 5. Selected introductions which demonstrated some resistance were tested a second or third time (Table 1).

TABLE 1—Resistance of selected pea introductions to Aphanomyces root rot

P.I. number	Disease index(*a*)			P.I. number	Disease index(*a*)		
	Test 1	Test 2	Test 3		Test 1	Test 2	Test 3
121976.....	4	6		180702.....	2	4	5
164669.....	3	6	6	180868.....	2	2	
165965.....	5	5		184128.....	3	5	3
166159.....	3	2	4	184129.....	4	3	2
167250.....	4	3	4	212916.....	4	7	
173059.....	3	2		244054.....	5	7	
179721.....	6	5	6	244154.....	5		
179969.....	6	5	4	244211.....	5		
180693.....	5	4	3	244226.....	4	3	

(*a*) Each accession was rated 0-8 with 0 indicating healthy plants and 8 indicating dead plants.

In these tests most of the lines showed a disease reaction similar to that given previously. No accessions immune or highly resistant to Aphanomyces root rot were found, but several lines gave demonstrable

Fig. 1. Aphanomyces root rot in 1) P.I. 169604 selection, 2) P.I. 180693, 3) Miragreen. 4) is healthy Miragreen. Note that roots of pea introductions show only slightly less decay than Miragreen but that tops of plants are not wilted.

though slight resistance under the conditions of the tests. In most cases this resistance was manifested in the tops of the plants which wilted more slowly, and in the epicotyls which were attacked less severely, than those of more susceptible lines (Figs. 1, 2, 3). Roots of the resistant introductions usually were only slightly less decayed (one-half a disease index unit) than those of susceptible accessions (Figs. 1, 2). In an occasional test, particularly with a lower concentration of zoospores than was normally used (Lockwood and Ballard, 1959) roots of the most resistant accessions were markedly less decayed than those of the commercial variety.

Fig. 2. Aphanomyces root rot in P.I. 166159 (left), and Miragreen (right). Note healthy epicotyls of P.I. 166159 as compared with discolored and collapsed epicotyls of Miragreen. Roots of P.I. 166159 are decayed.

In the case of Fusarium root rot, more accessions with higher levels of resistance were found. In the first screening 539 accessions had disease indices of 7-9, 185 were rated 4-6, and 69 were rated 1-3. The most resistant lines were selected for further testing (Table 2). Definite root and epicotyl resistance was shown by many lines (Fig. 4), but as was the case with Aphanomyces root rot no immunity was found.

DISCUSSION

The disease index given a particular introduction was sometimes not reproducible in a second test. Concurrently with the evaluation of plant introductions studies were made of variable factors affecting disease (Lockwood and Ballard, 1959), and attempts were made to improve the precision of the screening tests. The following factors were found to influence disease indices for Aphanomyces root rot: depth of planting, age of seedling at time of inoculation, rate of emergence of

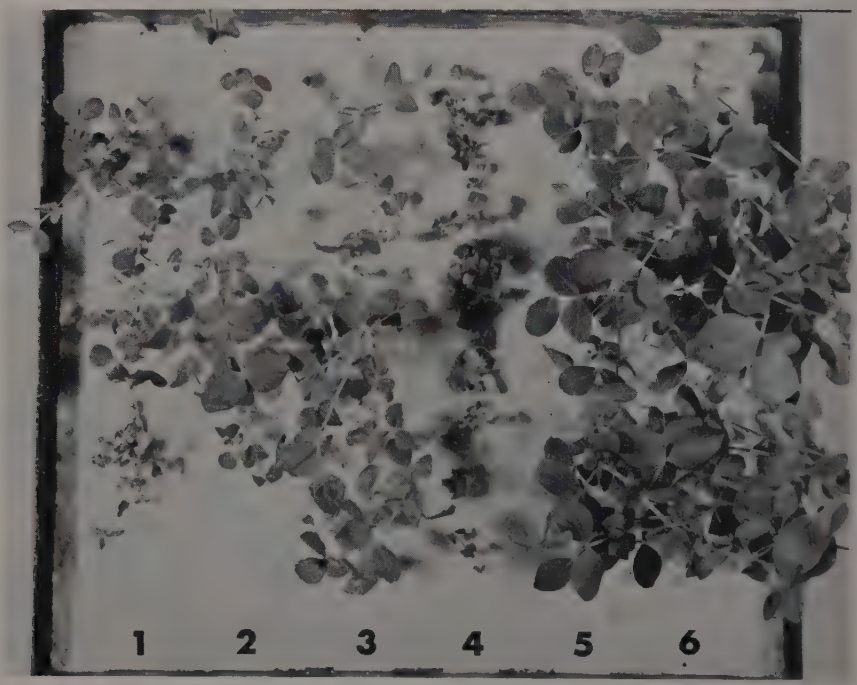

Fig. 3. Tops of various pea introductions affected with Aphanomyces root rot. 1, 2, and 3 are pea introductions showing slight resistance to wilting in tops; 4 is Miragreen, showing completely wilted plants; 5 and 6 are pea introductions with tops more resistant to wilting.

TABLE 2—Resistance of selected pea introductions to Fusarium root rot

P.I. number	Disease index(a)			P.I. number	Disease index(a)		
	Test 1	Test 2	Test 3		Test 1	Test 2	Test 3
134271	1	3		184128	2	2	
138945	1	1		184129	3		
140165	1	2		185183	3	6	
163131	3	3		193585	3	2	
164838	5	2		193590	3		
165949	4	2		195021	3	7	2
165965	3	1		195022	3	5	4
166051	3	4		195023	3	5	4
166082	3	3		195024	5	4	4
166084	2	2		195025	4	6	1
167253	4	2		196009	3	7	4
171814	2	5	2	196010	3	4	
171816	2	5	2	196014	5	3	
173055	1	2	1	196017	2	2	
173059	2	4		196018	3	3	
173778	2	7		196019	4	3	
173779	4	1		196021	3	4	2
173929	2	1		196022	4		
174917	1	1		197990	3	8	
174918	4	1	4	198072	4	3	
174919	1	1		198073	5	4	
174920	4			198735	5	4	
174921	4	3		202049	3	2	
174922	5	3	3	204306	5	1	
175230	3	9		206988	2	4	
175231	1	1		209506	2	5	
176721	4			210587	3		
177054	3	4		210651	3	8	
179019	3	3		212112	3	1	
179448	3	5		214064	4		
179449	1	3		220673	3	2	
179722	2			223284	3	1	
179969	4			223526	2		
180329	3			244095	3		
180694	2	3		244124	4		
180695	3	3		244125	4		
180868	2	1		244136	4		
181800	2	2		244138	4		
183068	2	3		244144	3		
183140	2	9		244205	3		
183336	4	2		244227	3		
183910	2	2					

(a) Each accession was rated 0-9 with 0 indicating healthy plants and 9 indicating dead plants.

seedlings, age of culture, concentration of zoospore suspension, volume of zoospore suspension, distance of placement of inoculum from row, and temperature of sand. Similar factors were controlled for the Fusarium root rot tests. With improved experimental conditions variability decreased, but still could not completely be eliminated. The expression of disease apparently is conditioned by factors in addition to those controlled in the screening tests. Possibly air temperature and moisture, which were not controlled, are involved.

Because of variability in disease and the fact that replications were not used in screening tests, disease indices in Tables 1 and 2 should be taken only as semiquantitative, i.e., lines should not be differentiated as to degree of resistance based on this data. It will be necessary to run repeated replicated experiments with the most promising accessions in order to find those with highest levels of resistance. This work is in progress.

In some introductions occasional individuals were found which appeared to be more highly resistant to the disease than the line as a whole, particularly in the early stages of the screening. Limited testing of seed of such selfed selections indicated that most if not all

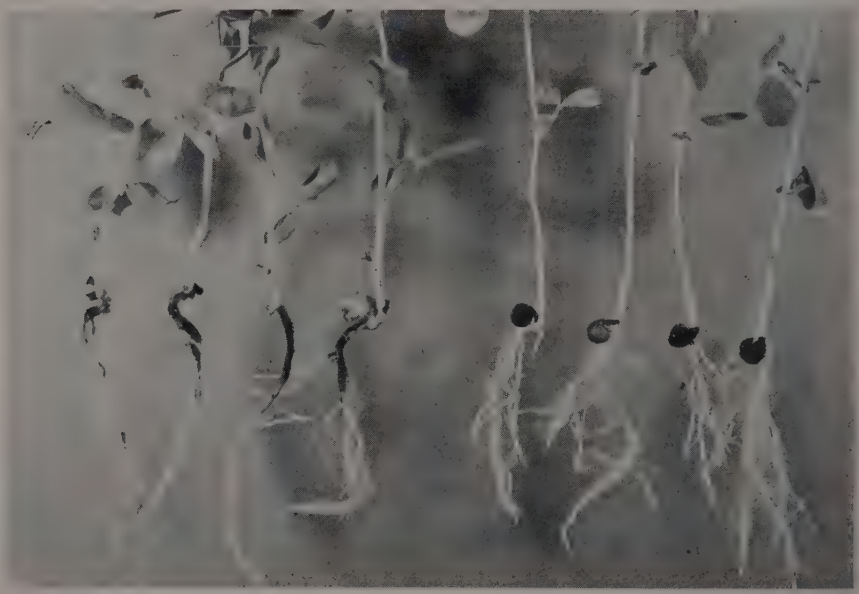

Fig. 4. Fusarium root rot in Early Perfection peas (left), and P.I. 140165 (right). Note severe decay of Early Perfection, particularly in region of upper tap root, and relatively slight decay in P.I. 140165.

of these were escapes or had a level of resistance no higher than accessions in Tables 1 and 2. Since many lines were decidedly heterogeneous with respect to seed type and other characters, it should not be surprising to find variation in susceptibility to disease. A selection of P.I. 169604 obtained from W. T. Schroeder and D. W. Barton at the New York Agricultural Experiment Station was more resistant than the parent line. The level of resistance of the selection was not, however, higher than the best of those accessions in Table 1.

It is possible that some accessions with resistance equal to those in Tables 1 and 2 were overlooked in the screening tests, or that some apparently resistant accessions may prove to be more susceptible in subsequent tests. It seems doubtful, however, that accessions or individuals more resistant than those selected are represented in the collection of pea introductions tested.

Accessions with consistently low disease indices may be useful as parent lines for breeding for resistance to root rots of pea. This would seem a particularly good and reasonable hope in the case of Fusarium root rot.

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SMOKE-FLAVORED CHEDDAR CHEESE

By T. I. HEDRICK, L. J. BRATZLER and G. M. TROUT

DEPARTMENTS OF DAIRY AND ANIMAL HUSBANDRY

INTRODUCTION

THE CONSUMPTION of smoke-flavored foods has been increasing in recent years, especially meat and fish products. High-protein Cheddar cheese with a smoke flavor has been readily available but sales have been relatively small. Preliminary investigation indicated need for improving the smoke flavor of the cheese if sales were to be stimulated. Consequently, this project was undertaken for that purpose and also to study related factors, such as keeping quality, appearance and acceptance.

Information is meager on the manufacture and merchandising of smoke-flavored Cheddar cheese. In 1925, researchers at the New York Agricultural Experiment Station developed a pasteurized processed cheese with a smoke flavor by the addition of distillation products from smoke concentrates. Later (1936), work at the same experiment station resulted in a natural cheese with a smoke flavor. The process consisted of adding one-tenth of one percent of liquid smoke before setting the milk.

Marquardt[1] reported the best results by the addition of 0.05 percent of liquid smoke product to the milk before cheese manufacture. If 0.1 percent were used a strong smoke flavor resulted and 0.02 percent gave a mild smoke flavor in the cured cheese. A year later he indicated that difficulty was encountered in obtaining a smoke flavor in Cheddar cheese by the application of smoked salt.[2] Two percent salt caused streaks and insufficient smoke flavor. A smoke house procedure for natural and processed Cheddar was attempted. It consisted of cutting 3- and 5-pound loaves lengthwise into halves and placing them upon a wire grid of ½-inch mesh. Exposure of the cheese to the smoke

[1]Marquardt, J. C. (1941). Smoked cheese. National Butter and Cheese Journal, 32: 28-29.
[2]Marquardt, J. C. (1942). Smoked cheese. National Butter and Cheese Journal, 33: 20-22.

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varied from 18 to 36 hours with 24 hours considered satisfactory. The temperature was maintained below 100° F.

EXPERIMENTAL PROCEDURE

In this study the Cheddar cheese was obtained from the Michigan State University Dairy Products Processing Plant. The cheese, selected at various stages of ripening, was trimmed and cut into various length 1½ to 2-inch rectangles, within 24 hours prior to smoking.

The slow smoke penetration into the Cheddar cheese ruled out the feasibility of using large-size pieces. Trials involving various rectangular shapes (cubes, slabs and bars) indicated the bar form had the most possibility in terms of surface area for smoke exposure and ultimate convenience for the consumer. A suitable dimension was roughly 2 by 2 by 10 inches. Eighteen bars were cut from a 40-pound, Wilson-type block.

The pieces of cheese were placed on ½-inch wire mesh screen shelving on a monorail rack in the smoking chamber. Placement permitted the smoke to permeate all sides of each piece. The cheese was manually inverted about midway during smoke exposure.

After initial trials, the smoking temperature was controlled by directing the smoke from the generator through water-cooled coils into the smoking room. The temperature range was approximately 10 degrees but, generally, was narrowed to 4 to 6 degrees. Attempts were made to keep the smoking room temperature under the melting point of the milk fat.

Immediately after completion of smoking, the monorail rack of cheese was conveyed directly into a refrigerated room and held at 36° to 40° F. overnight.

The cheese was removed from the shelving and wrapped in Saran (except for wrapping trials). Samples were selected at random and the remainder was held in a 35° F. cooler until distributed for sale.

The smoke was produced by a generator using dampened hardwood sawdust. Seventy pounds of sawdust provided a sufficiently dense smoke for a 5- to 6-hour contact with the cheese in the 400 cu. ft. smoking room.

Organoleptic examinations were made by experienced dairy product judges. Particular attention was paid to proper intensity of smoke and its blending qualities with the natural cheese flavor. In consumer

trials for acceptance or preference based upon taste, samples were submitted to dairy store customers and students.

Smoke-flavored cheese, using liquid concentrate, was made by adding 100 ml. of Wright's liquid smoke to each 330 pounds of whole milk prior to setting. Otherwise, the cheese was made according to accepted commercial practice. The ripening temperature was 47° to 49° F.

RESULTS

Shrinkage During Exposure to Smoke

A loss of weight occurred during the smoke exposure. It varied from 1.1 to 6.0 percent. The weighted average was 1.85 percent for 30 trials involving 2,600 pounds of Cheddar cheese. Except during short exposures, the fat tended to oil out of the cheese when the smoke-room temperature reached the average melting point of the milk fat or higher. The maximum temperature range while smoking was 91° to 94° F.; the minimum was 62° to 66° F. The loss of 4.0 percent for the higher range and 1.3 percent for the lower illustrates the greater shrinkage experienced with higher temperatures, although the relationship between temperature and weight loss was quite general.

Several individual factors or a combination of them influenced the attractiveness of the smoked product. The cheese had a marked tendency to lose its shape as the temperature increased above 85° F. Also, fat, which had seeped at temperatures of 85° F. or higher, formed a greasy covering upon cooling, thereby making the product less attractive. Unfiltered smoke, carrying small dark particles into the smoke room which settled on the cheese and stuck to the fat film, also increased unattractiveness.

Hours of Smoke Exposure

Aged cheese (cured 6 months or more) was subjected to smoke treatment for 1 to 8 hours. The average of six trials showed that 1 to 3 hours smoking generally was insufficient to yield the desired smoke flavor. On the other hand, 4 to 6 hours gave a pleasing intensity of smoke flavor, whereas 7 to 8 hours resulted in smoke flavor which was too intense.

The darkening of the cheese surface served as a rough index to the desired intensity of smoke flavor. During smoking, the surface changed from a light golden mottled appearance at the end of 1 hour to dark

brown by 8 hours. Generally, 1 to 2 hours smoking resulted in a light golden, mottled surface; 3 hours, a golden color without mottling; 4 hours, a light brown; 5 to 6 hours, a medium brown; whereas 7 to 8 hours yielded a brown to dark brown.

Six trials with mild cheese (cured 3 months or less) gave results, so far as smoke flavor and appearance were concerned, similar to those obtained on aged cheese. However, attainment of both desired flavor and color usually required approximately an hour longer in mildly cured cheese than in the aged.

Variations in the rate of smoke absorption and color change occurred among the six trials of both types of cheese. These were attributed to inconstant smoke density in the cheese smoke room which was difficult to maintain.

Subsequent production of smoke-flavored cheese for retail stores was standardized at 5 hours of smoking.

Keeping Quality

Preliminary trials, using different types of wrapping material, indicated an impervious wrapper was important in prevention of a gradual decrease in smoke flavor and loss of moisture during storage. Accordingly, the small samples of cheese for keeping quality tests (1 pound or less) were wrapped individually in Saran and heat-sealed before submitting them to various storage conditions.

Samples of cheese from the same lots were stored at 40° F. and at 54° F. Eighteen trials, with samples held at 40° F., showed the cheese to be in excellent condition at two weeks as far as body and color were concerned. Likewise, a loss in smoke flavor was not detected.

Generally, the same results were found at four-week storage. However, in three trials, a slight whitish salt-like material was noticed on a few surface areas. The six-week results also showed good body and flavor, but samples in two trials had a few mold spots; five had some areas with the salt-like appearance.

At eight weeks of storage, visual mold was noted on the cheese of 4 of 18 trials; 6 had limited areas of the salt-like discoloration. Nevertheless, smoke flavor was rated good in all 18 trials. Excessive surface mold at 10 and 12 weeks excluded these storage periods from being practical.

Fourteen trials were conducted with storage at 54° F. The body,

color and smoke flavor were scored "good" at the two-week inspection. The same results were observed at the end of four weeks, except two samples had small mold spots and two had slight salt-like areas on the smoke-exposed surface. By the end of six weeks, the two samples previously showing mold spots were definitely moldy; 12 were given a "good" rating in body and smoke flavor and four had small areas of salt-like discoloration. Most samples were moldy at the end of eight weeks.

Cheese at this storage temperature continued to develop flavor. Objectionable flavors increasingly masked the desirable smoke flavor.

Saran-wrapped samples in 15 trials were stored at –15° F. for 12 weeks. At the end of the storage period they were defrosted at 40° F. and examined after one day at that temperature. All samples were rated "good" for body, color and smoke flavor. Changes in smoke flavor as a result of storing at this temperature were not detected. When examined after 14 days at 40° F., the samples still showed good color. However, two samples had a "storage" flavor which seemed to mask the smoke flavor. Samples in four of the 15 trials had a noticeably dry, mealy body whereas, the others were rated "good".

Consumer Preference Study

In a preference study involving 30 hotel and restaurant students 22 preferred the smoke flavor in the medium cured cheese, while eight chose the aged cheese with smoke flavor. In taste trials among more than 100 retail dairy store customers, 38 preferred the aged cheese with smoke flavor; 62 selected the medium cured.

A third series of trials consisted of a preference comparison between aged cheese given the smoke flavor by exposure to hardwood sawdust smoke and a smoke-flavored, aged cheese that resulted from adding a liquid-smoke concentrate to the milk in the cheese manufacturing process. A total of 105 people were involved in the tasting. Eighty-eight percent preferred the cheese with direct sawdust smoke exposure while 12 percent chose the liquid-smoke variety. The usual comment on the liquid smoke-flavored cheese was that it was more astringent and, therefore, less pleasing in flavor.

A substantial majority of the customers patronizing the Michigan State University Dairy Store and an independent dairy store preferred the cheese with a medium degree of smoke flavor compared to a strong

smoke flavor. The smoke-flavored cheese sold at 10 cents a pound more than similar nonsmoked cheese. Nonetheless, smoked cheese sales increased the Cheddar type sales by approximately 45 percent. Cheddar cheese sales did not decrease when the smoke-flavored kind was put in the same display cabinet.

Discussion of Results

Shrinkage of Cheddar cheese during exposure to smoke from hardwood sawdust was due to the oiling-out of milk fat and moisture loss in the surface area. Therefore, smoking under cooler conditions, particularly below the melting point of the milk fat, inhibited the fat seepage. High humidities in the smoke house should decrease the rate of moisture evaporation from the cheese. Reports in literature on moisture loss during meat smoking indicate greater losses at low humidity. Gibbons[3] stated that bacon weight loss was inversely proportional to the humidity during smoking.

Resistance of cheese to smoke penetration necessitates cutting pieces which provide ample surface. This augments moisture loss but is necessary in order to get sufficient smoke in the surface layers to compensate for less of it in the interior. In general, shrinkage will not be serious if precaution is taken to maintain high humidity and the smoking temperature is at 80° F. or less.

The rate of smoke absorption requires 4 to 6 hours exposure for a medium flavor intensity. Longer exposure causes a higher concentration at the surface and is less pleasing to many consumers. Most people are accustomed to medium or mild flavors. Too much smoke also tends to mask natural cheese flavors. Consequently, the aim is to have just enough smoke flavor to blend well with natural flavors.

Smoke flavor in the amounts usually preferred will not cover objectionable flavors of poor quality cheese. Smoke absorption during a 6- or even 8-hour exposure does not prevent the subsequent cheese ripening processes at favorable storage temperatures. Germicidal influences occur at the surface of the cheese during the rind formation. Apparently incomplete penetration of the smoke to the center of the cheese does not prevent bacterial or enzymatic activity.

Differences in required smoke-exposure time is explained by the curing stage of the cheese and smoke density. Complete control of rate of smoke production is not feasible for a commercial installation.

[3]Gibbons, N. E. (1954). Bactericidal and drying effects of smoking on bacon. Food Tech., 8: 155-157.

The chimney draft, for example, will vary with atmospheric conditions and thus affect smoke density.

The more rapid smoke absorption of aged cheese indicates the by-products of cheese-curd changes during ripening have a greater affinity for the smoke than the original constituents do. Dehydration contributes to the rind formation but is not a major factor affecting color formation.

Maintenance of good-quality, smoke-flavored cheese during prolonged storage depends upon conditions preventing gradual dissipation of smoke and moisture and growth of surface mold. The more impervious the package, the slower these undesirable qualities develop. Low storage temperature is especially helpful in delaying troublesome mold growth.

Persons well informed on consumer food habits would probably expect most people to prefer a medium degree of smoke flavor in a mild or medium cured Cheddar cheese. Individuals accustomed to strong flavors would be expected to prefer an aged cheese with a strong smoke. In general, customers prefer the types and degree of flavor they have experienced previously. An acceptance of new, stronger cheese flavors usually has to be developed.

Since liquid-smoke concentrates contain acids, aldehydes, peptones, and phenols, in addition to other constituents, the astringent, smoke-type of flavor was not surprising. Not only did the liquid smoke fail to give as desirable a blend with the natural cheese flavors, but it was not considered as typically a smoke flavor as the hardwood smoke.

SUMMARY AND CONCLUSIONS

Hardwood sawdust smoke imparted a pleasant flavor to Cheddar cheese. Optimum smoking time for approximately 2-pound, bar-shaped pieces of Cheddar cheese was 4 to 6 hours for a medium intensity of smoke flavor. The time varied with the curing stage of the cheese and smoking conditions.

Cheese weight loss during smoking averaged 1.85 percent and ranged from 1.1 to 6.0 percent. In general, higher losses occurred when smoke-house temperatures approached the melting point of milk fat or higher and when lower humidities prevailed in the smoking chamber.

Smoke-flavored cheese wrapped in an impervious package (Saran) may be stored successfully for two months or more at 40° F. Likewise,

such cheese may be held at –15° F. for at least three months without impairment of flavor or body. Surface mold growth after extended storage may occur even at favorable growth temperature.

According to results of a consumer survey, Cheddar cheese flavored with liquid-smoke concentrate did not give as pleasing a smoke flavor as did that adequately exposed to hardwood smoke. Consumer preference definitely favored a medium over a strong smoke flavor in a medium cured cheese rather than the same desired intensity in aged cheese.

A smoke-flavored Cheddar cheese resulting from adequate exposure to hardwood-sawdust smoke will stimulate cheese sales.

DWARF FRUIT AND TREE DECLINE, A VIRUS DISEASE OF APPLE

By DONALD CATION

Department of Botany and Plant Pathology

A new disease of Hyslop crab apple trees named Dwarf fruit and tree decline, Cation and Gibson (1952), was disclosed in 1944 near Fennville, Michigan, where mature Hyslop trees in the Thomas Smith orchard and the U. S. Crane orchard were top worked with Jonathan scions. Both growers used the same source of scion wood and their trees reacted similarly.

The grafted scions grew vigorously for the first several years but later the grafted trees showed progressive decline. Terminal growth was reduced and lateral growth became sparse. Graft unions were weak and the grafted scions were easily separated.

The Jonathan fruit on the grafted branches was uniformly small, but normal in shape and flavor. This fruit was of "schoolboy" grade, a term applied locally for apples 1½ to 2¼ inches in diameter. The Hyslop fruit on the ungrafted branches was not only smaller than normal but also was distorted in shape, oblate, and more or less deeply five-lobed. The calyx end was truncate and the basin flat or shallow. Typically affected fruits are shown in Fig. 1.

The consistency of symptoms in 64 Hyslop trees grafted with one source of Jonathan and the lack of symptoms in another 64 Hyslop trees similarly grafted to another source of Jonathan at the U. S. Crane orchard coincidentally met all the requirements of a planned experiment on disease transmission. Alternate Hyslop trees, not grafted, were of good uniform vigor. As fungus and bacterial signs were absent, the disease was evidently of virus nature. Typical diseased and normal trees from this orchard are shown in Fig. 2.

Transmissibility was further demonstrated and additional observations were made in an experiment begun in 1945. One-year-old Hyslop trees were grafted with scions from the diseased source of either

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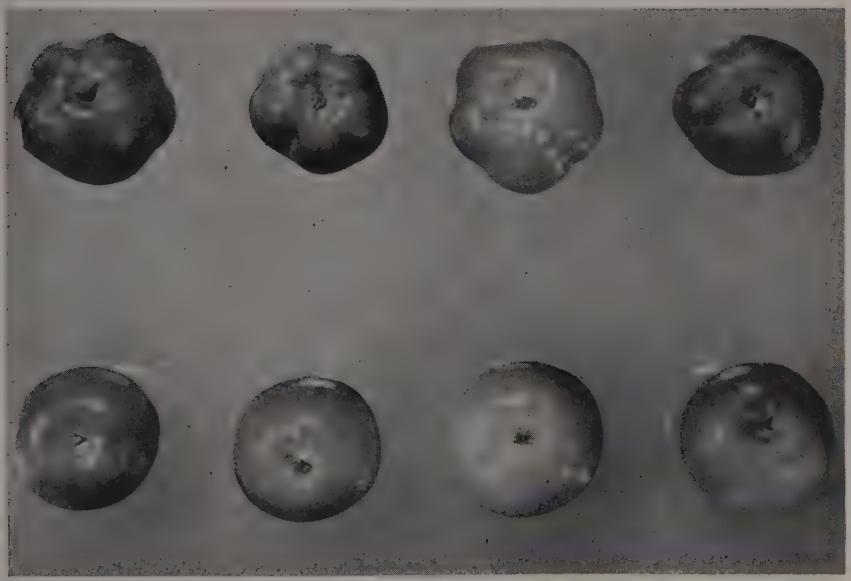

Fig. 1. Typical Hyslop fruits from dwarf fruit-diseased tree (top row) and normal tree (bottom row).

Fig. 2. On the left is a Hyslop grafted with virus-carrying Jonathan. The Hyslop on the right was grafted with normal Jonathan (U.S. Crane orchard, Fennville, Michigan 1944).

Jonathan or Hyslop and alternately planted in a row with ungrafted Hyslop using a 6-foot spacing between trees. The experiment has continued through 15 years.

The graft inoculated trees grew vigorously for two years but began to show decline in the third year. The uninoculated trees increased in size yearly while the inoculated trees became progressively weaker. Six of the nine inoculated trees died between the ninth and 12th years. Two of the remaining trees were lacking exceptionally in vigor and the third tree was but half the size of normal trees in the 15th year. After 15 years the three inoculated trees averaged 3½ inches in trunk diameter compared to a 6-inch average diameter for the other trees. Typical tree decline in this experiment at the end of the fifteenth year is illustrated in Fig. 3. Typically misshapen Hyslop fruit was observed in the fourth and later years.

Natural transmission to three trees was observed. One tree showed typical fruit symptoms in the 12th year and the other two trees in the

Fig. 3. The Hyslop tree in the center was innoculated with dwarf-fruit virus. This picture shows the comparison with two uninoculated trees after 15 years.

15th year of the test. Each tree that acquired the disease naturally was but 6 feet from an inoculated tree and the disease did not spread to trees in an adjacent row 16 feet distant. This indicates spread by natural root union.

The trees were examined for stem pitting in 1959 (Guengerich and Millikan, 1956). Trees showing fruit symptoms of the disease also were stem pitted. The normal trees showed smooth stems when strips of bark were peeled away from the trunks. Stem pitting of Hyslop also has been reported by Keane and Welsh (1959).

Inoculations to an indicator variety reported by Mink and Shay (1959) known as Russian 12740-7A gave reactions as early as 14 days. These reactions are frequently preceded by a bending of a tip shoot, and a few days later the two sides of adjacent leaves show unequal development. The leaves may also show chlorotic spots. Similar reactions are seen following inoculation with many other sources of apple that are also carrying similar stem-pitting viruses.

Inoculation with Dwarf fruit virus to Zumi and Hopa crab apple seedlings have resulted in variously mottled, puckered and necrotic-spotted leaves, in some, but not all, of the clones tested. The symptoms were repeated during the second year in the greenhouse.

DISCUSSION

The dwarf fruit disease apparently results from infection by a virus similar to other viruses reported to produce stem pitting. Viruses that cause stem pitting are demonstrated to occur more or less latent with no resulting symptoms in certain sources of our common apple varieties (Guengerich and Millikan, 1956; Mink and Shay, 1959). Infections result in marked tree decline only when the virus-containing sources are grafted to susceptible rootstocks, such as Virginia Crab, Hyslop, Spy 227 and certain other clones, particularly those with crab apple parentage. Very few discrete comparisons of the different variety sources known to carry the stem pitting factor have been made by grafting to Hyslop. However, in one such comparison, which will be presented in another publication, a McIntosh apple carrying the so-called Spy 277-lethal virus did not distort Hyslop fruit as severely as the Dwarf-fruit virus.

Stem pitting results from a disorientation of the Xylem cells of the wood and the phloem cells of the bark (Hilborn and Hyland, 1957). It can be stated that a diseased tree shows distinct depressions or pits in

the woody stem when the bark is peeled back and conversely these are matched by projections of tissue growing from the inner bark. Normal trees are smooth at the juncture of the bark and wood.

Tree decline accompanied by stem pitting became evident in recent years following a trend for double working trees, particularly where the Virginia Crab variety was used as a root stock (Guengerich and Millikan, 1956; Keane and Welsh, 1959; Mink and Shay, 1959; and Tukey et al., 1954). Virginia Crab is reputedly winter hardy (Lantz, 1933; and Maney, 1939), and furthermore is unpalatable to mice, (Toenjes, 1960). These are valuable attributes for a rootstock. Certain sources of scion wood do not transmit stem pitting and produce satisfactory trees when topworked on Virginia Crab. Such non-reacting varieties may be rapidly ascertained by testing them on R12740-7A. Comparisons of dwarf fruit disease and other sources of tree decline inoculum are not completed.

SUMMARY

A disease of Hyslop, descriptively named Dwarf fruit and tree decline was shown graft transmissible from symptomless Jonathan. The Hyslop fruit on diseased trees was stunted and misshapen. The Jonathan fruit was uniformly small in size but otherwise normal. The diseased Hyslop trees showed a severe type of stem pitting. They also transmitted epinasty, chlorotic mottle, necrosis and retardation symptoms when inoculated to the indicator variety R12740-7A. Certain Zumi and Hopa crab apple seedlings showed various forms of mottle, leaf puckering and necrosis when inoculated with the dwarf fruit virus.

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PRESENT STATUS OF RESEARCH ON GRAYWALL AND INTERNAL BROWNING OF TOMATO

By HARRY H. MURAKISHI

DEPARTMENT OF BOTANY AND PLANT PATHOLOGY

GRAYWALL (GW) AND INTERNAL BROWNING (IB) are two very similar-appearing disorders affecting the fruit of tomato. In both cases, the vascular region becomes necrotic so that the shoulder and wall of the ripening fruit when sectioned will have brown or brownish-gray streaks (Fig. 1), Boyle and Wharton (1957) and Conover (1949) (1957). IB has been demonstrated by Boyle and Wharton to be the result of late infection of plant by TMV (tobacco mosaic virus) and the invasion and accumulation of this virus in the fruits. On the other hand, GW was shown to be independent of TMV infection and was induced, not by a parasite, but by factors such as low light intensity,

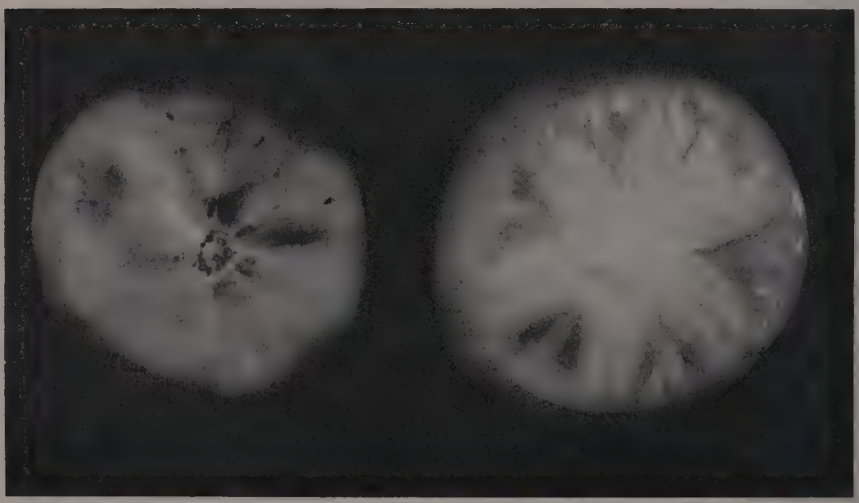

Fig. 1. Left, symptoms of graywall (GW) and internal browning (IB) and right, healthy fruit.

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low air temperature, Hall and Dennison (1955), and high soil moisture, Hall and Dennison (1955) and Taylor et al., (1958). Based on present information, GW and IB cannot always be distinguished from each other on the basis of symptoms alone. It should, however, be possible to differentiate the two disorders by testing for presence or absence of TMV in the plants and fruits.

VARIETAL REACTION

The varieties Manalucie and Indian River were reported to be resistant to GW in Florida, Hayslip et al. (1958), while Strain A Globe was resistant to GW in Ohio, Jones and Alexander (1956). Resistance to IB, however, has not been found in any commercial variety but freedom from mosaic symptoms and from IB was observed by Holmes (1950) in a field-grown plant introduction, later designated as P.I. 235673. Walter (1956) found resistance to TMV in certain plant introductions, but made no mention of their reaction to GW or IB.

In 1958, surveys and virus assays on sensitive local lesion tobacco hosts of necrotically-affected fruits collected on southern Michigan farms revealed that both GW and IB occurred together. It is believed that the unusually high incidence of ripening disorders, as high as 75 percent on some farms, may be attributable to the simultaneous occurrence of GW and IB. Although reports concerning the reaction of tomatoes to either GW or IB alone have been noticed Hayslip et al. (1958), Holmes (1950), and Jones and Alexander (1956), the writer was not able to find any reference to a study of the simultaneous reaction of any tomato to both GW and IB. In light of the 1958 observations, it was deemed worthy of investigation to determine whether a variety resistant to one disorder might also be resistant to the second. The following study was made to determine the simultaneous GW and IB reaction of three varieties, each different in their reaction to GW or to TMV.

MATERIALS AND METHODS

Seedlings of Fireball, Manalucie and P.I. 235673 were transplanted in replicated, paired five-plant rows. A total of 10 plants of each variety was subjected to each of the following four treatments: Low light-TMV free, low light-TMV infected, high light-TMV free, and high light-TMV infected. The low light treatment was achieved by covering the plants with a mesh shading cloth that cut out approximately 50 per-

cent of the light. The unshaded row of each paired row represented the high light series. Inoculation of plants with TMV and shade treatments were imposed from the time the fruits on the first cluster were about ⅔-¾ grown. All plants were indexed on *Nicotiana tabacum* var. Xanthi just prior to the treatments and were found to be virus-free. In order to prevent accidental infection of the TMV-free treatments, no one was permitted in the test plots until four weeks after the initiation of the experiment when fruits were harvested on an individual plant basis. When a presumably GW fruit occurred on an uninoculated plant, both the fruit and a young leaf from the plant were indexed for virus. In all cases where GW fruits had occurred, no virus was ever isolated either from the fruits or plants. TMV-inoculated Fireball and Manalucie plants manifested mosaic symptoms by the end of the experiment and assays of fruits and plants of these two susceptible varieties showed a high titre of TMV.

RESULTS

Fig. 2 shows the incidence of GW and IB in fruits harvested from the plants subjected to the four treatments. In the low light-TMV free series, 15 percent of Fireball fruits were affected with GW, but Manalucie was completely free of GW. P.I. 235673 showed about 1 percent GW. In the high light-TMV free treatment, Fireball had 6 percent GW; Manalucie, less than 1 percent and P.I. 235673, none.

In the low light-TMV infected series, Fireball had 29 percent IB; Manalucie, 31 percent; and P.I. 235673, about 2 percent. In the high light-TMV infected treatment, Fireball had 18 percent IB; Manalucie, 27 percent and P.I. 235673, less than 2 percent IB. Virus assays showed only a trace of TMV in P.I. 235673 while, as previously stated, Fireball and Manalucie had a high concentration of the virus.

DISCUSSION AND SUMMARY

The results confirm earlier experiments in the greenhouse, Murakishi (1959), and those of others, Hall and Dennison (1955), that GW may be induced in TMV-free plants by low light intensity or shading. The data further show that low light plus TMV-infection substantially increased the incidence of IB in Fireball and Manalucie. P.I. 235673, which is resistant to TMV, also was found to be resistant to GW as well as to IB.

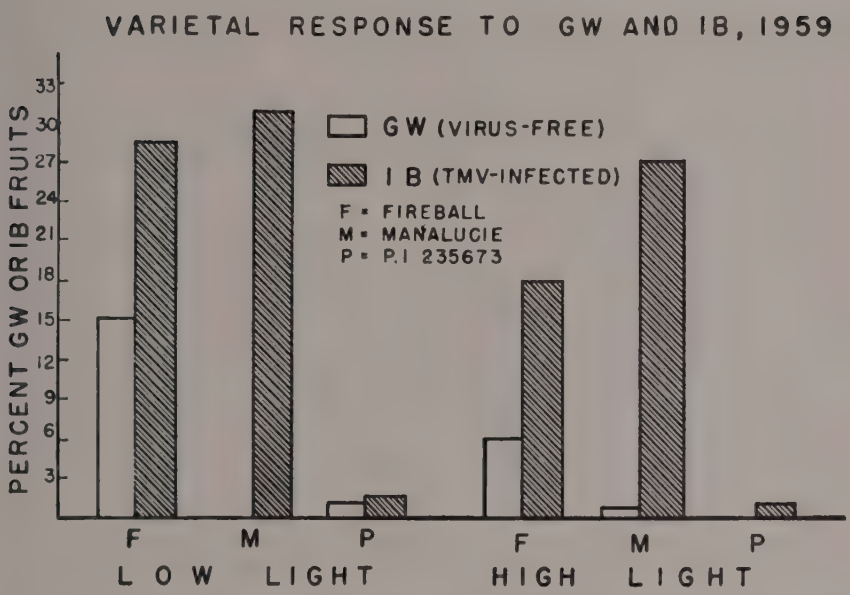

Fig. 2. Reaction of tomatoes to graywall (GW) and internal browning (IB).

From the point of view of reducing losses due to these two ripening disorders, it is clear that avoidance of TMV infection prevents IB. Based on this experiment, the prevention of TMV infection in the case of Fireball could mean an 18-29 percent reduction in total fruit losses. In manalucie, freedom from TMV infection might result in virtually all healthy fruit since the experiment showed that this variety apparently carries a high level of resistance to GW.

Obviously, the most desirable method of control would be to incorporate TMV resistance with the desired horticultural characters. Such a variety would then presumably have resistance to both disorders. Studies are in progress to investigate this possibility.

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THE EFFECT OF PLANTING DATE ON THE YIELDS OF FOUR SPRING WHEAT VARIETIES

By S. M. KING

Department of Farm Crops and
Upper Peninsula Experiment Station

The average spring wheat yields in the Upper Peninsula are low, viz. 19 bushels per acre. Because of these low yields, a study was conducted to ascertain the effects of date of planting on yield, test weight, and days required to mature the grain.

In an Iowa study with oats, Wiggans (1956) concluded that there was a decrease in yield from oats seeded after the middle of April. A Utah experiment conducted by Woodward (1956) showed that when three plantings of spring wheat were made one month apart, the earliest planting yielded 77 bushels per acre and the second and third plantings, 53 and 34 bushels, respectively.

Brown (1957) calculated yields of several spring wheat varieties planted at different dates in 1945 and 1946 at East Lansing, Michigan. Wheat planted on March 16 and April 11, 1945, yielded 34.6 and 24.7 bushels per acre, respectively. In 1946, plantings on April 4 and May 7 yielded 28.5 and 14.2 bushels, respectively.

METHOD

Each test plot consisted of four rows 12 feet long with 1 foot between rows. The seeding rate was 7 pecks per acre. No fertilizer was placed with the seed; 400 pounds per acre 5-20-20 (1957) and 4-12-24 (1958) were drilled across the plot area prior to planting. The soil tested high in phosphorus and potassium.

The plots were planted on April 29, May 6 and May 13, 1957 and May 2, May 9 and May 16, 1958. Each test included the varieties Henry, Lee, Russell and Selkirk in six replications (Table 1).

Ten feet of the two center rows in each plot were harvested for yield. All yields are expressed in bushels per acre.

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RESULTS AND DISCUSSION

In 1957, yield decreases from later planting dates were highly significant; in 1958, they were significant at the 5 percent level. Combining both years resulted in a decrease, significant at the 1 percent level (Table 1).

TABLE 1—Yields of four spring wheat varieties seeded on three dates one week apart. Chatham, 1957-58

Variety	Planting date											
	1957				1958				1957-58			
	1st	2nd	3rd	Ave.	1st	2nd	3rd	Ave.	1st	2nd	3rd	Ave.
Henry	37.7	31.9	23.7	31.1	37.0	32.6	31.8	33.8	37.3	32.3	27.8	32.5
Lee	33.5	30.8	25.7	30.0	33.6	34.6	31.7	33.3	33.6	32.7	28.7	31.7
Russell	37.8	34.5	29.3	33.9	36.2	30.7	32.3	33.1	37.0	32.6	30.8	33.5
Selkirk	43.4	31.1	27.3	33.9	38.6	32.7	32.0	34.4	41.0	31.9	29.7	34.2
Average	38.1	32.1	26.5		36.4	32.7	32.0		37.2	32.4	29.2	
Difference required for significance(*a*) at												
	R.E.	L.S.D.			R.E.	L.S.D.			R.E.	L.S.D.		
5% level	3.0	2.9		N.S.	3.5	3.3		N.S.	2.2	2.05		N.S.
1% level	4.3	4.1			4.7	5.0			2.9	2.8		

(*a*) Based on Duncan's multiple-range test (1955). A difference less than the L.S.D. (R_2) is not significant. A difference between the date of planting averages greater than the R.E. value is significant. R.E. = Range of equality.

There was no significant difference in yield between varieties. However, an examination of yield differences due to late planting shows that the yield loss of the Lee and Russell varieties was much

TABLE 2—Length of growing season of four spring wheat varieties seeded on three dates, one week apart. Chatham, 1957-58

Variety	Days required to mature grain to binder-ripe stage						
	First planting		Second planting		Third planting		Average
	1957	1958	1957	1958	1957	1958	
Henry	106	118	105	115	106	112	110
Lee	103	112	102	108	101	106	105
Russell	106	119	105	116	106	113	111
Selkirk	103	115	102	112	101	110	107
Average	110		108		107		

less than that of Henry and Selkirk. Expressed arithmetically, the average yield loss from a two weeks' planting delay was 8 bushels. Selkirk was a higher yielder than Russell when both were planted early, but Russell outyielded Selkirk at later planting dates.

Data regarding maturity are shown in Table 2. Lee was ready for harvest six days earlier than Russell and had the highest test weight. However, Lee produced the lowest yields of the four varieties, and was more susceptible to rust and loose smut (King, 1958). The number of days required to mature the grain varied greatly between years, probably because of near-normal temperatures in 1957 contrasted with below-normal temperatures in 1958.

The departures from long-time average temperatures were as follows:

	May	June	July	August
1957.....	0.4	−0.4	0.5	−1.2
1958.....	−1.6	−4.9	−2.6	−0.8

In the "normal" summer of 1957, the yield drop as a result of planting late was much greater than in the extremely cool summer of 1958, when the grain took longer to mature.

In addition to a yield decrease, delayed planting resulted in a sizable decrease in test weight (Table 3). In both years, there was very little loss of test weight between the first and second plantings,

TABLE 3—Test weights of four spring wheat varieties seed on three dates, one week apart. Chatham, 1957-58

Variety	Test weight (lb. per bushel)						
	First planting		Second planting		Third planting		Average
	1957	1958	1957	1958	1957	1958	
Henry.....	62.0	60.0	62.0	60.0	58.5	58.5	60.2
Lee.....	62.0	62.0	62.0	61.0	61.0	59.0	61.2
Russell.....	62.0	62.0	62.0	59.0	58.0	59.0	60.3
Selkirk.....	61.0	60.0	61.0	60.5	58.5	57.0	59.7
Average.....	61.4		60.9		58.7		

whereas a two-week delay resulted in a weight loss of more than 2 pounds per bushel.

There was very little rust infestation, no mildew and no lodging during the two growing seasons.

SUMMARY AND CONCLUSIONS

Four spring wheat varieties were planted on three dates one week apart in 1957 and 1958 at Chatham.

There was a significant yield decrease due to delayed planting. This decrease was significant at the 1 percent level in 1957 and over both years, but was significant only at the 5 percent level in 1958.

There was no significant difference between average yields of the four varieties. The decrease in yield due to delayed planting was, however, proportionately greater for Henry and Selkirk than for Lee and Russell. Selkirk should be planted as early as possible, preferably about May 1 in areas with a climate similar to that at Chatham. If later planting is necessary, Russell is the most reliable variety.

A yield loss of 4 bushels per acre per week and a test weight loss of more than 2 pounds per bushel were the result of delayed planting.

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THE EFFECT OF NITROGEN FERTILIZER ON YIELD AND PROTEIN CONTENT OF ALFALFA AND COMPANION CROPS

By C. R. CARTER and H. D. FOTH

Department of Soil Science

Field observations in 1952 showed that nitrogen fertilization resulted in more rapid establishment and growth of alfalfa seedlings established in wheat the previous fall.[1] Uncertainty existed, however, in regard to the effect of nitrogen on the yield of forage. This led to experiments to determine the extent and significance of the effect of nitrogen fertilization on yield and protein content of alfalfa and companion crops. This paper presents the results of experiments where nitrogen fertilizer was applied to: (a) alfalfa grown in the greenhouse, (b) seedings made in the field with three different companion crops, and (c) established stands of the crop.

METHODS

A greenhouse study involving rates of nitrogen fertilization was carried out on Miami loam, Brookston clay loam, Oshtemo loamy sand, Conover loam, Hillsdale loam, and Fox sandy loam. Nitrogen fertilizer was applied at the time inoculated alfalfa seeds were planted.

Extensive field experiments were carried out using different rates of nitrogen, dates of seeding, and wheat, oats, and barley as companion crops on three of the soils used in the greenhouse experiment.

Thirty pounds of nitrogen per acre was applied as a topdressing on four established stands of alfalfa using ammonium sulfate, ammonium nitrate and urea as sources of nitrogen. Soils on which the experiments were located were the Oshtemo loamy sand, Ockley sandy loam, Bellefontaine sandy loam, and Conover loam.

Some properties of the soils are given in Tables 1 and 2. Phosphorus and potassium were determined by the Spurway reserve method.

[1] Swenson, R. M. (1953). Unpublished data. Mich. Agr. Expt. Sta.

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TABLE 1—Composition of the plow layer of soils used in the greenhouse and in field experiments involving companion crops

Soil type	pH	Percent organic matter	Percent nitrogen	Pounds per acre(a)	
				Phosphorus	Potassium
Miami loam.....	6.3	2.2	0.125	16	87
Brookston clay loam....	6.9	4.9	0.200	78	120
Oshtemo loamy sand...	6.8	0.7	0.043	9	56
Conover loam.....	7.2	3.8	0.157	72	64
Hillsdale loam.....	6.4	2.2	0.113	50	150
Fox sandy loam.....	6.6	1.2	0.077	50	200

(a) Extracting solution was 0.13 N HCl.

Ammonium sulfate was used as a source of nitrogen in all experiments. Ammonium nitrate and urea were used, in addition to ammonium sulfate, in the experiment where established stands of alfalfa were topdressed. Percent protein was determined by multiplying the percent of nitrogen obtained with the Kjeldahl method by 6.25.

RESULTS AND DISCUSSION

Greenhouse studies.

Addition of up to 160 pounds of nitrogen per acre to alfalfa grown in the greenhouse produced average yield results for three successive cuttings which varied with soil type. Nitrogen fertilization of alfalfa grown on the Oshtemo loamy sand and Miami loam resulted in statistically significant yield increases over the check yields (Table 3). Smaller increases in yield were found in Conover loam. On the Brook-

TABLE 2—Composition of soils used in the experiment where established stands of alfalfa were topdressed with nitrogen.

Soil type	pH		Pounds per acre(a)			
			Phosphorus		Potassium	
	Surface	Subsoil	Surface	Subsoil	Surface	Subsoil
Oshtemo loamy sand....	6.8	6.1	28	20	·233	62
Ockley sandy loam.....	5.8	5.6	53	42	178	62
Bellefontaine sandy loam	6.8	6.2	39	35	67	21
Conover loam.....	6.4	6.2	72	22	275	137

(a) Extracting solution was 0.13 N HCl.

ston and Hillsdale soils, nitrogen fertilizing increased yields only slightly and no increase occurred on the Fox sandy loam.

Average yield of alfalfa from all soils for three successive cuttings gave small, consistent, but not satistically significant increases with increased rate of nitrogen fertilization.

The effect of nitrogen on yields decreased with cuttings. The average yield for three successive cuttings from six soils was increased 9 percent over the check, with 160 pounds of nitrogen per acre, while the increase for the first cutting only was 19 percent. The latter was significant at the 5 percent level of probability.

TABLE 3—Effect of nitrogen on the average yield and percent protein of three cuttings of alfalfa grown in the greenhouse

Pounds N per acre	Oshtemo loamy sand		Miami loam		Conover loam		Brookston clay loam		Hillsdale loam		Fox sandy loam		Average	
	Yield (a)	Percent protein	Yield	Percent protein	Yield	Percent protein	Yield	Percent protein	Yield	Percent protein	Yield	Percent protein	Yield	Percent protein
0.....	6.9	15.5	8.1	18.0	8.2	17.2	11.0	19.0	9.4	17.7	11.5	18.2	9.2	17.6
20.....	7.3	15.9	8.1	18.6	8.3	17.8	11.6	19.2	10.2	17.7	10.9	18.3	9.4	17.9
40.....	8.3	16.0	10.0	16.9	8.7	18.7	10.7	18.0	10.2	19.0	11.1	19.4	9.8	18.0
80.....	8.3	16.1	10.2	18.1	8.4	18.1	11.5	18.7	11.1	19.5	10.8	18.8	10.0	18.2
160.....	8.7	17.0	9.0	19.3	8.7	18.6	12.9	17.4	10.4	19.9	11.4	18.8	10.2	18.5
L.S.D. 5%..	1.5	N.S.	2.0	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.

(a) Grams oven-dry alfalfa per pot.

These results are in accord with other investigations. Allos and Bartholomew[2] have shown that nitrogen fertilization can increase growth and reduce nitrogen fixation by legumes.

Addition of nitrogen resulted in a small increase in protein content of alfalfa grown on all soils except the Brookston (Table 3). None of these increases were significant at the 5 percent level. A small but consistent increase in the percent of protein with increased nitrogen fertilization was found when data for all soils were averaged together. There was a highly significant difference in the protein content of alfalfa produced on different soils and for different cuttings, with the higher protein content found in the earlier cuttings.

When the total protein produced was calculated from the average yield and percent protein data given in Table 3, significant differences were found between nitrogen treatments as well as between soils. Total protein produced was parallel to the rate of nitrogen applied.

[2]Allos, H. F. and W. V. Bartholomew (1955). Effect of available nitrogen on symbiotic fixation. Soil Sci. Soc. Amer. Proc. 19: 182-184.

Field results.

The effect of nitrogen fertilization on yield and protein content of oats and barley, when sown with alfalfa, is shown in Table 4. Yield of oats increased with increasing rates of nitrogen on the Fox sandy loam. Yields were decreased on the Hillsdale loam due to lodging. Twenty pounds of nitrogen resulted in a highly significant increase in yield of barley on the Brookston soil. Very small increases were found beyond this rate of application.

The protein content of the grain was increased significantly for both crops at all locations (Table 4).

TABLE 4—The effect of nitrogen on yield and the percent protein of grain of companion crops

Pounds N per acre	Fox sandy loam		Hillsdale loam		Brookston clay loam	
	Yield(*a*)	Percent protein	Yield(*a*)	Percent protein	Yield(*b*)	Percent protein
0	44	12.6	73	12.1	44	10.4
20	56	14.1	68	12.9	55	10.7
40	56	14.9	57	14.1	57	11.5
80	60	15.6	55	14.2	56	12.2
L.S.D. 1 percent..	10	1.1	N.S.	2.1	7	0.9
L.S.D. 5 percent..	—	—	N.S.	1.5	—	0.6

(*a*) Bushels per acre of oats.
(*b*) Bushels per acre of barley.

Two cuttings of alfalfa were harvested during each of the next two years following its establishment with oats and barley. Alfalfa, which had been established without a companion crop on the Hillsdale and Brookston soils, also was harvested. Nitrogen applied at the time of seeding the alfalfa, with or without a companion crop, resulted in no effect on yield of the first cutting of alfalfa the next year in two cases; small decreases in yield in two cases, and a small increase in one case out of five. The average of these indicates that the addition of 40 and 80 pounds of nitrogen per acre caused a very small decrease in yield of the first cutting, equal to about one-tenth of a ton per acre. The total hay produced in four cuttings, over a two-year period, was unaffected by nitrogen treatments.

The effect of nitrogen fertilization on establishment of the seedings was not recorded. However, fertilization practices which may cause

a more rapid establishment of alfalfa seedlings do not necessarily result in an increase in yield of forage the following year.[3]

The percent protein in the first two cuttings of hay was influenced very little, if at all, by nitrogen applied at establishment. The percent protein of the alfalfa hay was 15.9, 16.2, 16.1 and 16.1 percent for 0, 20, 40 and 80 pounds of nitrogen per acre, respectively.

Wheat was also used as a companion crop at these three locations. Alfalfa was seeded with wheat in the fall and also overseeded with wheat in the spring. The wheat was top dressed with 20 pounds of nitrogen per acre at the time of overseeding. The yield of wheat varied little between locations, regardless of nitrogen treatment or nitrogen top dressing. However, small yield increases were statistically significant in four cases out of six due to nitrogen treatment in the fall and in two cases out of six due to top dressing. When all treatments were averaged, yields increased from 34.7 to 41.5 bushels for the 80 pound rate of nitrogen. On the average, there was no increase in yield due to nitrogen top dressing.

Protein content of the grain was increased in almost every case where nitrogen was applied either as a top dressing or at planting (Table 5).

Test weights were made on all grain samples and it was found that this weight was not seriously affected, even with the addition of 100 pounds of nitrogen per acre.

Nitrogen applied when wheat was planted in the fall had essentially no effect on the weight of the first cutting of alfalfa harvested following the wheat (Table 6). Addition of 20 pounds of nitrogen per acre as a top dressing in the spring, however, caused a significant decrease in alfalfa yields. In every case, except where no nitrogen was applied in

[3]Brown, B. A. (1959). Band versus broadcast fertilization of alfalfa. Agron. Jour. 51: 708-710.

TABLE 5—The effect of nitrogen fertilization on percent protein in the grain of wheat grown with and without 20 pounds of nitrogen applied as a top dressing in the spring

Pounds N per acre	Fox sandy loam		Hillsdale loam		Brookston clay loam	
	0	20	0	20	0	20
0	9.9	11.1	11.7	12.5	11.4	11.5
20	10.5	12.8	12.1	12.4	11.0	11.5
40	12.2	14.2	12.0	12.7	10.9	11.6
80	13.0	14.5	12.9	13.1	11.5	11.5

the fall on the Fox sandy loam, yield of the first cutting of alfalfa the following year was decreased as a result of top dressing with nitrogen. These decreases occurred for both the fall and spring-sown alfalfa which are averaged together in Table 6.

Nitrogen fertilization of wheat in the fall or of oats and barley in the spring had no real effect on yield of the first cutting of alfalfa. However, nitrogen fertilization of an established companion crop, such as top dressing wheat in the spring, decreased yield of first cutting of alfalfa the following year.

There was no effect of nitrogen fertilizer on protein content of the hay the following year.

Thirty pounds of nitrogen was applied to established stands of alfalfa at four locations in southern Michigan in 1957 about 10 weeks before the first cutting. Ammonium sulfate, ammonium nitrate and urea were used separately. Yield and protein content of the first cutting of hay were not increased significantly.

TABLE 6—Effect of nitrogen fertilizers applied to wheat on yield in tons-per-acre of the first cutting of alfalfa following the wheat. Up to 80 pounds of nitrogen were applied in the fall and 20 pounds as a spring top dressing(a)

Pounds N per acre	Fox sandy loam		Brookston clay loam	
	0	20	0	20
0	1.4	1.4	2.0	1.9
20	1.5	1.3	2.1	1.8
40	1.3	1.2	2.1	1.8
80	1.3	1.2	2.1	2.0

(a) Average of fall and spring sown alfalfa.

SUMMARY AND CONCLUSIONS

Nitrogen fertilization:

1. Increased yield and protein content of alfalfa grown in the greenhouse.

2. Did not increase yield or protein content of alfalfa, established with or without a companion crop, when fertilizer was applied at the time of establishment in the field.

3. Did not increase yield or protein content of forage when applied to established stands of alfalfa.

4. Increased yields and protein content of the grain of companion crops.

5. Reduced the first cutting yield of alfalfa forage, which was established in wheat, when the nitrogen was applied at the rate of 20 pounds per acre as a top dressing in the spring.

It is concluded that:

1. The rate of nitrogen fertilization of alfalfa and companion crops sown in the spring, should be determined by considerations relating to the companion crop. Up to 80 pounds of nitrogen per acre did not depress yield of forage.

2. Nitrogen top dressing of wheat in the spring can reduce the first cutting yield of alfalfa established in this crop. Consideration should be given to establishment of alfalfa after wheat harvest.

3. It is not profitable to apply nitrogen to established stands of alfalfa.

ESTABLISHMENT AND FERTILIZATION OF LEGUME-BROMEGRASS HAY

By H. D. FOTH, R. M. SWENSON and R. L. COOK

DEPARTMENT OF SOIL SCIENCE

CONSIDERABLE UNCERTAINTY has existed with the establishment of legume and legume-grass mixtures in Michigan. This has been particularly true in regard to their establishment in winter wheat. Experiments initiated in 1951 were designed to study certain management factors contributing to this uncertainty. Those studied in regard to establishment were planting date, type of companion crop and fertilizer rate and analysis. Factors studied concerning maintenance of the stands were fertilizer rate, analysis and time of application.

PROCEDURE

Experiment 1 was started in the fall on an area where the soil is predominantly Conover loam. It is an imperfectly drained and moderately dark-colored member of the Gray-Brown Podzolic great soil group. The solum of the modal soil is slightly to medium-acid throughout. It has a clay loam-textured B horizon, which has a mottled-gray, yellow, and brown color. The soil developed from loam-textured calcareous till.

Experiments 2, 3 and 4 were located adjacently. These soils were somewhat more variable and also included those ranging from Brandt loamy sand to Brookston silty clay loam.

A split-plot randomized block experimental design with four replications was used in each experiment. Two cuttings of hay were made each year with the first about June 20, and the second the first week in August. All seedings, except those made in the spring over wheat, were made with a standard grain drill without presswheels.

Experiments 1 and 2 were designed to study establishment and maintenance of alfalfa-bromegrass. The main treatments of experiment 1 involved time of seeding and type of companion crop on the

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establishment of seedings. Fertilizer subtreatments were designed to study the influence of nitrogen on establishment and maintenance of the stand. Experiment 2 was a more comprehensive fertilizer analysis and rate experiment to obtain more information on the value of phosphate and potash fertilizer on stand maintenance.

One and one half bushels of Eaton oats and Yorkwin wheat, 8 pounds of Montana Grimm alfalfa and 3 pounds of Canadian bromegrass were seeded per acre. All plots in experiment 1 received 1 ton of lime per acre. Those in experiment 2 were limed according to soil test.

In the spring of the third harvest year, the fertilizers in experiment 1 were reapplied as a topdressing, using the same amounts of phosphorus and potassium. Nitrogen applications were 30 and 60 pounds per acre for subtreatments C and D, respectively.

Experiment 3 was a fertilizer analysis and rate experiment in which red clover and bromegrass were sown with an oats companion crop. Rates of seeding and varieties of oats and bromegrass were the same as those in experiment 1. Red clover was sown at 8 pounds per acre. The establishment treatments were the same as those used in experiment 2, but subtreatments were different. These treatments are given in Table 5.

Experiment 4 was designed to test further the effects of nitrogen on fall versus spring seeding of alfalfa in wheat (treatments 1 and 2 of experiment 1). Varieties and seeding rates for wheat and alfalfa were again the same as those in experiment 1. The treatments are given in Table 2.

RESULTS AND DISCUSSION

Effect of companion crop and time of seeding on establishment of alfalfa-bromegrass.

Significant yield differences resulting from the establishment treatments were found for each of the eight alfalfa-bromegrass cuttings in experiment 1 (Table 1). Greatest differences in yields occurred in the first harvest year and the differences decreased with time.

Establishment of alfalfa-brome without a companion crop (treatments 4 through 7) resulted in wide variations in first-yields. These differences can be explained on the basis of moisture supply and weed competition. The superiority of establishing alfalfa-brome alone in June and August is clearly evident. The summer fallowing resulted

TABLE 1—Yields of two cuttings of alfalfa-brome grass hay per year as influenced by establishment treatment and fertilization in experiment 1

Treatments to establish alfalfa-brome grass	Tons per acre														
	1953			1954			1955			1956			4 year average		
	1st	2nd	Total	1st	2nd	Total	1st	2nd	Total	1st	2nd	Total	1st	2nd	Total
1. With wheat in the fall	1.11^{bc}(*a*)	.65^{bc}	1.76	1.62^{b}	.45^{b}	2.07	1.84^{c}	.91^{c}	2.75	1.70^{c}	.48^{b}	2.18	1.56	.62	2.19
2. Sown over wheat in the spring	.99^{c}	.56^{c}	1.55	1.65^{b}	.52^{b}	2.17	1.90^{bc}	1.06^{bc}	2.96	1.84^{bc}	.68^{ab}	2.52	1.60	.71	2.30
3. Sown with oats in April	1.31^{b}	1.10^{a}	2.41	2.17^{a}	.82^{a}	2.99	2.22^{ab}	1.29^{ab}	3.51	2.11^{ab}	.77^{a}	2.88	1.95	1.00	2.95
4. Sown alone in April	1.12^{bc}	.89^{ab}	2.01	1.95^{ab}	.76^{a}	2.71	2.07^{abc}	1.35^{a}	3.42	2.09^{ab}	.83^{a}	2.92	1.81	.95	2.77
5. Sown alone in June	1.61^{a}	1.05^{a}	2.66	1.99^{ab}	.85^{a}	2.84	2.16^{abc}	1.27^{ab}	3.43	1.91^{abc}	.51^{b}	2.42	1.92	.92	2.84
6. Sown alone in August	1.65^{a}	.92^{ab}	2.57	2.11^{a}	.77^{a}	2.88	2.00^{abc}	1.23^{ab}	3.23	2.01^{ab}	.64^{ab}	2.65	1.94	.89	2.83
7. Sown alone after oats harvest	.84^{c}	.94^{ab}	1.78	2.01^{ab}	.74^{a}	2.75	2.27^{a}	1.29^{ab}	3.56	2.17^{a}	.80^{a}	2.97	1.82	.94	2.77
Mean	1.23	.87	2.11	1.93	.70	2.63	2.07	1.2	3.27	1.98	.67	2.65	1.80	.86	2.66
Level of significant mean difference	1%	1%		1%	1%		5%	1%		5%	5%				
Fertilizer subtreatments															
A. No fertilizer	.85^{b}	.69^{b}	1.54	1.47^{b}	.55^{b}	2.02	1.34^{b}	.91^{b}	2.25	1.40^{b}	.54^{b}	1.94	1.27	.67	1.94
B. 0+120+60(*b*)	1.40^{a}	.91^{a}	2.31	2.11^{a}	.74^{a}	2.85	2.24^{a}	1.31^{a}	3.55	2.24^{a}	.76^{a}	3.00	2.00	.93	2.93
C. 20+120+60	1.39^{a}	.97^{a}	2.36	2.11^{a}	.78^{a}	2.89	2.35^{a}	1.31^{a}	3.66	2.12^{a}	.69^{a}	2.81	1.99	.94	2.93
D. 40+120+60	1.31^{a}	.92^{a}	2.23	2.02^{a}	.74^{a}	2.76	2.33^{a}	1.27^{a}	3.60	2.14^{a}	.71^{a}	2.85	1.95	.91	2.86
Mean	1.24	.87	2.11	1.93	.70	2.63	2.07	1.20	3.27	1.97	.67	2.64	1.80	.86	2.66
Level of significant mean difference	1%	1%		1%	1%		1%	1%		1%	1%				
Level of significance of T x F interaction	N.S.	N.S.		5%	N.S.		5%	5%		N.S.	N.S.				

(*a*) Any two means that do not have the same letter are significantly different and any two means having the same letter are not significantly different as calculated by Duncan's shortest significant range test.

(*b*) Pounds of N, P_2O_5 and K_2O per acre, respectively.

in a more favorable moisture supply. These later planting dates also resulted in reduced competition with weeds when compared to establishment alone in April (treatment 4). Ragweeds were very thick in the seedings established in April and on July 14 the plots were clipped at a height of 6 inches. Dexter (1953) likewise found that alfalfa seedings made in the latter part of the summer were less weedy than those made earlier.

Establishment of alfalfa-brome alone in August after oats harvest (treatment 7) resulted in the lowest yield. Water was probably a limiting factor because oats had been harvested from these plots the previous month. The rainfall for August, September, and October of the establishment year (1952) was 2.5 inches less than the long-time average. The most favorable combination of moisture conditions and weed competition resulted when the seedings were made alone in June and August on fallowed land.

Seedings were made with a companion crop in the first three treatments. The presence of oats did not have a detrimental influence on yields (compare treatments 3 and 4). In fact, they appeared to result in less competition for the seeding than did the weeds that grew in the absence of the oats.

The conventional method of seeding in April with oats was considerably superior to that of seeding alfalfa-brome with wheat in the fall, or over-seeding the wheat in the spring. This is due to the lateness of fall seeding and competition from wheat in the spring.

The recommended planting date for wheat is generally too late to make a successful fall seeding of alfalfa because the plants are not well enough established to survive the winter. When alfalfa is overseeded in the wheat in the spring, it meets with considerable competition from the established wheat plants. This is especially true if wet soil delays seeding or if extreme drought occurs after seeding. Nitrogen topdressing of wheat in the spring can also be expected to result in poorer alfalfa seedings (Carter and Foth, 1960).

The spring seeding of alfalfa-bromegrass in wheat (treatment 2) outyielded the fall seeding (treatment 1) in three out of four years. Experiment 4 was designed to obtain additional information on the influence of nitrogen on establishment of alfalfa in wheat. Here the spring established seeding again outyielded the fall seeding (Table 2). Visual observations made in the summer of 1954 showed fall-sown plots had fewer alfalfa plants than those sown in the spring. The results of experiments 1 and 4 indicate winter injury was more detrimental to

TABLE 2—Yields of two cuttings of fall and spring sown alfalfa in wheat in experiment 4

Treatments	Tons per acre						Total
	1955			1956			
	1st	2nd	Total	1st	2nd	Total	
1. Seed wheat in fall and alfalfa in fall..	1.83	.80	2.63	1.65	.48	2.13	4.76
2. Seed wheat in fall and alfalfa in spring	1.92	1.17	3.09	2.48	1.13	3.61	6.70
Level of significant mean difference..	5%	5%		1%	5%		
Subtreatments							
A. 0+120+60(*a*).....	1.86	1.01	2.87	2.19[a](*b*)	.86[b]	3.05	5.92
B. 20+120+60.....	1.91	1.04	2.95	1.82[b]	.79[b]	2.61	5.56
C. 40+120+60.....	1.75	.91	2.66	1.95[ab]	.62[c]	2.57	5.23
D. 40+240+120.....	1.99	.99	2.98	2.31[a]	.95[a]	3.26	6.24
Level of significant mean difference.	N.S.	N.S.		1%	1%		

(*a*) Pounds of N, P_2O_5 and K_2O per acre, respectively.
(*b*) See footnote of table 1.

late fall seedings than was the competition of a growing wheat crop on the spring seeding.

Role of Nitrogen in Fall Establishment of Alfalfa-Bromegrass.

Establishment of alfalfa-bromegrass in the fall with wheat in experiment 1 was benefited by nitrogen fertilization. Yields in the first harvest yield showed a consistent increase as the nitrogen rate increased. The yield without nitrogen (treatment B) was 1.56 tons per acre. When 20 and 40 pounds of nitrogen (treatments C and D) were used, yields were 2.13 and 2.22 tons, respectively. This indicated insufficient nitrogen mineralization, due to a low soil temperature, may have been a factor in the poor establishment of late fall seeding. Fertilizer subtreatments in experiment 4 were designed to test this idea.

There were significant yield differences due to fertilizer in the second harvest year (1956), but a comparison of subtreatments A, B, and C showed that increasing amounts of nitrogen at seeding time did not increase average hay yields the following year (Table 2). Inspection of the data for individual treatments failed to show evidence of an increase in yield in 1955 due to adding nitrogen fertilizer to fall established alfalfa. The greater yields caused by treatment D likely resulted from the additional phosphorus and potassium.

Factors contributing to ineffectiveness of the nitrogen fertilizer in this experiment, when compared to experiment 1, may have been

associated with differences in planting dates. Experiment 4 was initiated on September 7 while experiment 1 began October 1. The average temperature and solar radiation were 10 and 24 percent higher, respectively, in September, October and November when experiment 4 was started and may have resulted in greater mineralization of soil nitrogen.

The relatively high organic matter content of the imperfectly drained soils on which these experiments were conducted also may have been a contributing factor to the lack of a response to nitrogen during the year when the seeding was made early in the fall. Carter and Foth (1960) found that nitrogen fertilization of fall established alfalfa in wheat did not increase yields of forage at two locations in southern Michigan in 1957.

Effect of Fertilization on Yields.

Phosphate and potash fertilizer applied at the time of establishment and as a topdressing in the spring of the third harvest year resulted in approximately a 50 percent increase in yields in experiment 1 (Table 1). Nitrogen in the fertilizer at the time of establishment or as a topdressing did not increase the over-all average yields (compare subtreatments B, C and D). However, as pointed out earlier, nitrogen did increase the 1953 yields of alfalfa-brome fall sown in wheat. In summary, the fertilizers caused significant increases in yields, as compared to the check, but no single fertilizer produced yields which were significantly different from that of any other. In 1955, the year in which the plots were topdressed in April, yields were about 25 percent greater than in 1954 or 1956.

For the first cutting in 1954 and both cuttings in 1955, there was a significant treatment-fertilizer interaction. In 1954 the interaction was barely significant. In the case of the cuttings made in 1955, after topdressing the previous April, the effect of the nitrogen on the total hay yield is believed to be related to the extent to which it increased the growth of bromegrass relative to alfalfa.

The estimated percent of alfalfa in the first cutting in 1955 was considerably less where alfalfa-bromegrass was established with wheat (treatments 1 and 2) then where established according to the other five treatments (Table 3). Treatments 1 and 2 also showed the most pronounced and consistent yield increase as the amount of nitrogen in the fertilizer increased and explains why the treatment-fertilizer interaction occurred.

TABLE 3—Estimated percent of alfalfa in the forage at the time of the first cutting in experiment 1

Treatments	Year				Average
	1953	1954	1955	1956	
Main treatments to establish alfalfa-bromegrass					
1. With wheat in the fall	24	40	41	26	33
2. Sown over wheat in the spring	20	44	34	37	34
3. Sown with oats in April	80	74	58	52	66
4. Sown alone in April	72	69	63	44	62
5. Sown alone in June	82	82	71	51	71
6. Sown alone in August	93	80	62	42	69
7. Sown alone after oats harvest	71	70	63	42	61
Fertilizer subtreatments					
A. No fertilizer	58	57	52	58	56
B. 0+120+60	63	65	58	39	56
C. 20+120+60	68	70	58	31	57
D. 40+120+60	64	71	57	36	57
Average	63	66	56	41	

Effect of fertilizer rate, analysis and time of application on both establishment and maintenance of alfalfa-brome was studied in experiment 2 (Table 4). Fertilizer treatments applied at establishment caused significant yield differences for the first three cuttings, about 30 percent more than the check plots.

Fertilizer subtreatments resulted in highly significant yield differences for all eight cuttings over the four-year period. Yields of the check plots were 84 percent as high as the fertilized plots.

The subtreatments, which contained fertilizers B through F, did not result in any striking differences. Four-year average yields were similar. The presence of nitrogen in treatment C (compare C with B) was ineffective. There is no evidence that 60 pounds of potash was more effective than 30 pounds. Fertilizers used were equally good and the time they were applied was of little importance. There is an indication however that the yearly application was slightly more effective than biennial application when equal amounts of phosphorus and potassium were applied (subtreatment B compared to D).

The effect of fertilization on yield of red clover-bromegrass is shown in Table 5. Application of fertilizers containing phosphorus and potassium, alone or with nitrogen at the time of establishment, resulted in forage yields that were about two times greater than the check.

A comparison of treatments 2, 3 and 4, where the amounts of phosphorus and potassium were constant but the amount of nitrogen

TABLE 4—The effect of fertilizer analysis and rate on the yields of two cuttings per year of alfalfa-bromegrass hay in experiment 2

Treatments (when oats were planted)	Tons per acre														
	1955			1956			1957			1958			4 year average		
	1st	2nd	Total	1st	2nd	Total	1st	2nd	Total	1st	2nd	Total	1st	2nd	Total
1. No fertilizer	.74[b](b)	1.02[b]	1.76	1.90[c]	1.38	3.28	1.29	1.51	2.80	1.54	.97	2.51	1.37	1.22	2.59
2. 40+120+60(a)	1.48[a]	1.38[a]	2.86	2.30[ab]	1.68	3.98	1.38	1.54	2.92	1.66	.97	2.63	1.71	1.39	3.10
3. 20+120+60	1.42[a]	1.24[a]	2.66	2.14[abc]	1.45	3.59	1.41	1.50	2.91	1.72	.86	2.58	1.67	1.26	2.93
4. 0+120+60	1.38[a]	1.29[a]	2.67	2.14[abc]	1.64	3.78	1.37	1.60	2.97	1.64	1.05	2.69	1.63	1.39	3.02
5. 40+120+60(c)	1.19[a]	1.29[a]	2.48	2.08[bc]	1.48	3.56	1.36	1.40	2.76	1.54	.82	2.36	1.54	1.25	2.79
6. 60+120+60(c)	1.21[a]	1.22[a]	2.43	2.21[abc]	1.47	3.68	1.35	1.46	2.81	1.56	.83	2.39	1.58	1.25	2.83
7. 60+240+120(c)	1.55[a]	1.41[a]	2.96	2.47[a]	1.71	4.18	1.46	1.70	3.16	1.90	1.06	2.96	1.85	1.47	3.32
Mean	1.28	1.26	2.54	2.18	1.54	3.72	1.37	1.53	2.90	1.65	.94	2.59	1.62	1.32	2.94
Level of significant mean difference	1%	5%		5%	N.S.		N.S.	N.S.		N.S.	N.S.				
Subtreatments (applied after establishment)															
A. No fertilizer	1.17[c]	1.16[cd]	2.37	1.79[b]	1.19[c]	2.98	1.22[b]	1.32[de]	2.54	1.23[d]	.75[d]	1.98	1.35	1.11	2.46
B. 0+60+30 spring of each year	1.35[ab]	1.43[a]	2.78	2.31[a]	1.53[b]	3.84	1.39[ab]	1.55[bc]	2.94	1.70[b]	.99[ab]	2.69	1.69	1.37	3.06
C. 0+60+30 spring of each year	1.43[a]	1.29[abc]	2.72	2.25[a]	1.59[ab]	3.84	1.37[ab]	1.46[cd]	2.83	1.72[b]	.89[bc]	2.61	1.69	1.31	3.00
D. 0+120+60 spring of second harvest year	1.15[c]	1.25[bcd]	2.40	2.19[a]	1.61[ab]	3.80	1.38[ab]	1.43[de]	2.81	1.42[c]	.78[c]	2.20	1.53	1.27	2.80
E. 0+60+60 spring of each year	1.34[ab]	1.33[ab]	2.67	2.32[a]	1.64[ab]	3.96	1.44[a]	1.64[b]	3.08	1.95[a]	1.08[a]	3.03	1.76	1.42	3.18
F. 0+60+60 after first cutting each year	1.24[bc]	1.12[d]	2.36	2.20[a]	1.71[a]	3.91	1.44[a]	1.77[a]	3.21	1.92[a]	1.13[a]	3.05	1.70	1.29	2.98
Mean	1.28	1.26	2.54	2.18	1.54	3.72	1.37	1.53	2.73	1.66	.94	2.59	1.62	1.30	2.91
Level of significant mean difference	1%	1%		1%	1%		1%	1%		1%	1%				

(*a*) Pounds of N, P_2O_5 and K_2O per acre, respectively.
(*b*) See footnote of table 1.
(*c*) 40 lbs. of the nitrogen was applied after the oats emerged.

ranged from 40 to 20 and zero pounds per acre, respectively, shows that nitrogen did not increase hay yields. In both cuttings of the first harvest year, 1953, there was no significant difference in yields caused by these three treatments. The yield of the first cutting in 1956, when this experiment was conducted a second time, was lowered significantly where 40 pounds of nitrogen was applied (treatment 2 compared with 3 and 4). Total yields for both years suggest a decreasing hay yield trend with increasing amounts of nitrogen fertilizer at the time of seeding with an oats companion crop. Gerwig (1958) found that nitrogen fertilization of alfalfa, sown alone in August in New Jersey, reduced the stand and yield. Evidence indicates that nitrogen fertilization at the time of legume seedings occasionally may increase yields of forage, but it also may decrease the yields.

Topdressing the red clover-brome in the spring of the first harvest year with 0-30-15 had little influence on yields. In only one cutting in four was the yield significantly increased (Table 5).

Yields of oats in 1952 were positively correlated (significant at the 5 percent level) with yields of red clover forage in 1953 in experiment 3. Fertilization at establishment resulted in increased yields of both

TABLE 5—Yields of red clover-bromegrass and percent red clover in the hay in experiment 3. The experiment was conducted twice and in each case two cuttings of hay were harvested

Treatments at planting time	Tons per acre						Estimated percent red clover in the first cutting in 1953
	1953			1956			
	1st	2nd	Total	1st	2nd	Total	
1. No fertilizer	.58[c](b)	.62[b]	1.30	.81[d]	.20	1.01	51
2. 40+120+60(a)	1.56[ab]	.82[ab]	2.38	1.57[c]	.48	2.05	81
3. 20+120+60	1.71[a]	.84[ab]	2.55	1.92[ab]	.50	2.42	82
4. 0+120+60	1.73[a]	.88[a]	2.61	1.99[a]	.47	2.46	84
5. 0+120+60+40 lbs. N after oats emerge	1.49[ab]	.83[ab]	2.32	1.75[abc]	.46	2.21	78
6. 20+120+60+40 lbs. N after oats emerge	1.38[b]	.85[a]	2.33	1.56[c]	.46	2.02	79
7. Same nitrogen as in 6 with sufficient P_2O_5 and K_2O to test 5 p.p.m. P and 20 p.p.m. K using Spurway active test (60+240+120)	1.74[a]	1.01[a]	2.74	1.66[b]	.41	2.07	78
Level of significance mean difference.	1%	1%		5%	N.S.		
Subtreatments							
A. No further treatment	1.46	.80	2.26	1.59	.41		76
B. 0+30+15 in spring of clover year	1.45	.87	2.32	1.63	.44		76
Level of significant mean difference.	N.S.	1%		N.S.	N.S.		

(a) Pounds of N, P_2O_5 and K_2O per acre, respectively.
(b) See footnote of table 1.

grain and forage during the following year. The average yield of grain was increased 63 percent and forage 91 percent. Average increases in yields for all experiments (except 4, where there is no check) were 39 and 79 percent, respectively, for the grain and forage.

Increased growth of the companion crop due to fertilization most likely increased competition for space, water and light, but this was perhaps more than offset by reduced competition for nutrients or by fertilizer carry-over. The importance of adequate fertility during the period of establishment of forage crops is indicated by the results of Doll, *et al* (1959) in Kentucky. They found that light fertilization at the time of establishment could not be offset by heavy fertilization later, even though the total amount of fertilizer was doubled.

Effect of establishment treatment and fertilization on the botanical composition of forage.

Table 3 shows that establishment of alfalfa-brome in winter wheat resulted in stands averaging about 33 percent of alfalfa over a four-year period compared to 60 and 70 percent when seedings were used with oats or when sown alone. The percent of alfalfa increased with time for treatments 1 and 2 due to the increased size of the plants in the thinner stands. Alfalfa percentages decreased with time on the other plots, probably due to increased competition from the bromegrass.

Fertilizers appeared to have no over-all influence on the average percent of alfalfa in the stand in experiment 1. The data (Table 3) indicate a rather constant percent of alfalfa in the stand without fertilization (treatment A) over the four-year period. When fertilizers were used, the initial percent of alfalfa in the stands was greater but it decreased with time so that after four years it was below the non-fertilized plots. Fertilizers applied as a topdressing in the spring of the third harvest year appeared to have no effect on decreasing the amount of alfalfa in the forage.

All three fertilizers (treatments B, C and D) gave similar results. Apparently nitrogen in the fertilizer did not significantly increase the amount of bromegrass relative to alfalfa. Parsons (1957) similarly found that nitrogen fertilization had little influence on the composition of alfalfa-brome stands in Ohio. In the case of alfalfa and orchard grass, however, he found that nitrogen fertilizer greatly increased the amount of grass and decreased the alfalfa yield.

As was the case in experiment 1, one of the most interesting observations from experiment 2 was the tendency for the forage to contain a higher percent of alfalfa without fertilization at the end of the 4-year harvest period (Table 6). This was true for both the main and subtreatments. In addition, differences between the fertilizers are lacking or very small. Perhaps the differences in the fertilizers were not great enough to appreciably affect the yield or botanical composition of the forage. The ability of the alfalfa to persist without fertilizers in experiment 1 and 2 is being studied further. Preliminary investigations indicate it is related to the relative competitive capacity of alfalfa and bromegrass for nutrients in the soil.

TABLE 6—Estimated percent of alfalfa in alfalfa-bromegrass forage at the time of the first cutting in experiment 2

Treatments	Year			Average
	1955	1956	1958	
Main treatments				
1. No fertilizer	71	91	87	83
2. 40+120+60(*a*)	73	78	71	74
3. 20+120+60	69	83	77	76
4. 0+120+60	74	83	80	79
5. 0+120+60+40 lbs. N after oats emerge	69	81	81	77
6. 20+120+60+40 lbs. N after oats emerge	65	80	68	71
7. Same nitrogen as 6 with sufficient P_2O_5 and K_2O to test 5 p.p.m. P and 20 p.p.m. K using Spurway active test (60+240+120)	74	80	81	78
Subtreatments				
A. No fertilizer	66	83	83	77
B. 0+60+30 spring of each year	73	82	76	77
C. 10+60+30 spring of each year	73	83	77	78
D. 0+120+60 spring of second harvest year	70	83	76	76
E. 0+60+60 spring of each year	74	82	78	78
F. 0+60+60 after first cutting each year	68	81	76	75
Average	71	82	78	77

(*a*) Pounds of N, P_2O_5 and K_2O per acre, respectively.

Fertilizers applied at establishment had more effect on red clover-bromegrass than on first year alfalfa-bromegrass forage so far as botanical composition is concerned (Tables 5 and 6). Fertilization increased the percent of red clover in the forage from 51 to 80 percent. Little variation resulted, however, from the different fertilizer treatments applied at planting. This indicates again, as it did in experiments 1 and 2, that the differences in the fertilizers were probably too small to produce real differences in yield and botanical composition. Top-

dressing with phosphorus and potassium in the spring of the first harvest year did not affect the percent of red clover in the forage in 1953.

CONCLUSIONS

1. Yields of alfalfa-bromegrass in the first harvest year were closely related to establishment treatment. Differences were related to moisture supply, plant competition, and time of seeding. Seedings made in wheat in the fall or spring, or alone after oats harvest, were considerably inferior to those made with oats in April or those made alone on fallowed land in April, June and August.
2. The effect of establishment treatment on yields decreased with time. However, seedings made with wheat remained inferior throughout the four-year harvest period.
3. Alfalfa-bromegrass seedings made over wheat in the spring out-yielded those made in the fall with wheat.
4. Nitrogen fertilization of fall-sown alfalfa-bromegrass increased forage yields in one case out of two.
5. Nitrogen fertilization, up to 60 pounds of nitrogen per acre at establishment of alfalfa-bromegrass in the spring, or as a topdressing on established stands, did not affect the yield of forage.
6. Nitrogen fertilization, up to 60 pounds of nitrogen per acre, of red clover-bromegrass at establishment resulted in small decreases in the yield of forage the following year.
7. Phosphorus and potassium fertilization gave highly significant increases in yield of alfalfa-bromegrass forage when applied at the time of establishment or as a topdressing on established stands. Fertilizers applied at establishment resulted in yield differences which lasted for three cuttings.
8. Phosphorus and potassium fertilization at establishment of red clover-bromegrass resulted in significant increases in yield three cuttings out of four. Topdressing in the spring resulted in a significant increase in yield one cutting out of four.
9. Fertilizers applied when the companion crops and seedings were established, increased significantly the yields of both the companion crop and the forage the following year.

10. The botanical composition of alfalfa-bromegrass hay was greatly influenced by establishment treatment and to a smaller extent by phosphorus and potassium fertilization. During the first harvest year, the fertilized plots produced forage which had a greater percent of alfalfa than the non-fertilized plots, while the reverse was true for the fourth harvest year.
11. Phosphorus and potassium fertilization of red clover-bromegrass at establishment resulted in a 30 percent increase in the amount of red clover in the forage. Topdressing with phosphorus and potassium in the spring had no effect.
12. Sixty pounds of nitrogen per acre had little or no effect on the percent of alfalfa or red clover in the forage.

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SOME DEMAND AND PRICE CHARACTERISTICS FOR EGGS — M.S.U. CONSUMER PANEL[1]

By G. G. QUACKENBUSH

Department of Agricultural Economics

For almost eight years, from February 1951 to December, 1958, an average of about 250 families reported on their food purchases each week. They were members of the Michigan State University Consumer Panel operated in Lansing, Michigan. Weekly food reports included the quantity, price, grade, size, and expenditures for eggs. Over the eight-year period, more than 100,000 food purchase diaries were returned by panel members. Some reported every week, or nearly every week, for one or more calendar years. It was possible, therefore, to analyze yearly purchases in relation to other variables.

In this article an analysis of some of the data from the panel which relate to demand and price are presented.

Seasonals by Egg Sizes

The panel provided information on seasonal responses to price differences between sizes of eggs. It is common for pullets to come into egg production in late summer and fall. Accordingly, large numbers of small and medium-sized eggs are produced at this time. These are marketed at prices lower than large eggs. In Fig. 1 it may be noted that the price difference between large and small eggs widened sharply right after mid-year, and as a consequence consumers doubled and quadrupled their purchases of small eggs. By the 10th four-week period (September), the price spread had more than doubled. The quantity of small eggs purchased was about 14 times as great as in the spring months and they had replaced about 20 percent of the market for large eggs.

[1]M.S.U. Consumer Panel Report No. 57. For further information on the details of the Consumer Panel see Shaffer, J. D., and G. G. Quackenbush, (1955) Cooperation and sampling in four years of M.S.U. Consumer Panel operation. Mich. Agr. Dept. Sta. Quart. Bul. 38: 85-103.

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As pullets mature, egg sizes get larger. About a month after the greatest price spread between large and small eggs, the price difference between large and medium becomes widest. Panel families responded by doubling purchases of medium eggs. Accordingly, medium eggs replaced another 20 percent of the large-egg market.

Neither the price spread between extra large and large eggs, nor the quantity of extra large eggs, showed wide seasonal variation.

Panel members bought some eggs not graded by size. These amounted to about 15 to 20 percent of all eggs purchased. The

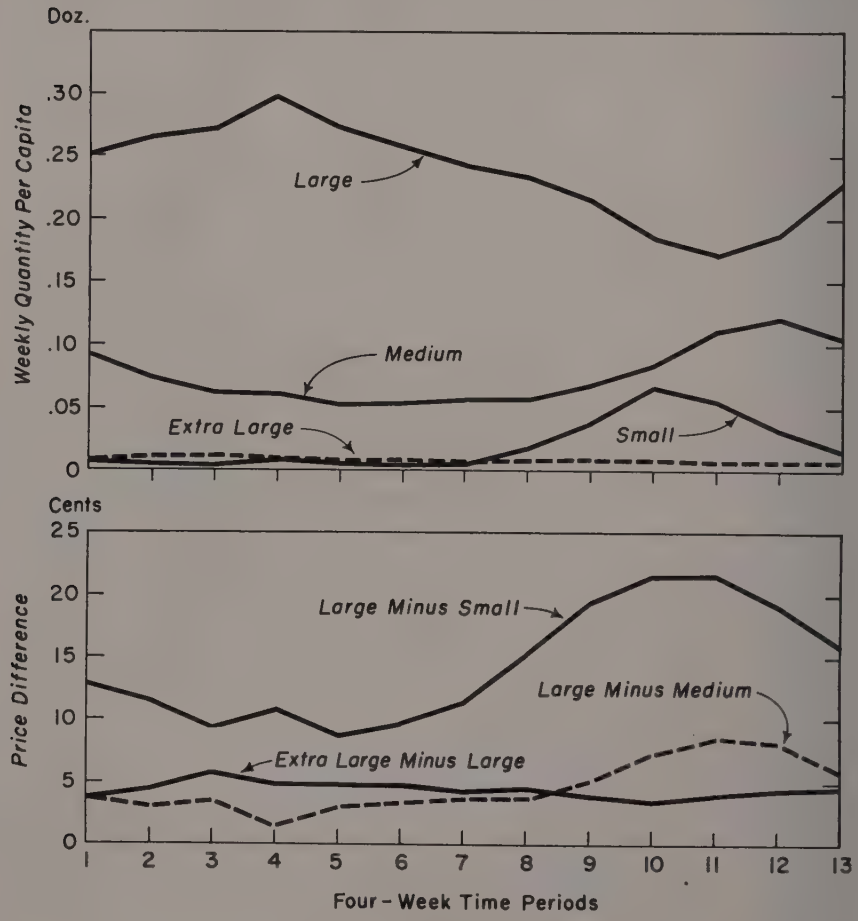

Fig. 1. The top chart shows the per capita quantity of eggs of various sizes purchased weekly. The bottom graph shows the price difference between sizes, mean of 4-week periods, 1952-1958, M.S.U. Consumer Panel.

quantity purchased was about 25 percent larger in the summer than in other seasons. The price of these eggs followed closely that for medium-sized eggs. Other sizes were jumbo, pee-wee and mixed, but there were so few bought that the data were not tabulated.

Data for the seven-year period are contained in Table 1.

TABLE 1—Average quantity, price, expenditure, and percent buying eggs, by sizes, 1952-58, M.S.U. consumer panel

Size	Average quantity per person weekly	Average price per dozen	Average expenditure per person weekly	Average percent of families buying weekly
	(dozen)	(dollars)	(dollars)	(percent)
All eggs	.429	.514	.214	66.9
Extra large	.008	.590	.005	1.5
Large	.237	.544	.124	39.1
Medium	.077	.497	.038	13.4
Small	.021	.400	.008	3.2
No size indicated	.080	.480	.035	11.6

Relationship of Family Purchases to Yearly Prices

During a four-year period, 1955 to 1958, there were 889 instances in which families sent in 50 or more diaries during the calendar year. In many cases, families had as many as four years of complete or nearly complete reporting, but in the analysis of the data each year's record was treated as an individual observation. Actually, 302 different families composed the 889 instances or observations.

The question arises as to whether or not families buying eggs at a lower price eat more of them. If the low price were due to buying small eggs, one might expect families to buy more; or if the family had a source where large eggs could be bought more cheaply, they would be expected to eat more. However, this hypothesis was not borne out by the data (See Table 2). The quantity per 100 meals at home was no greater when prices were low than when they were high. The higher prices, however, were associated with higher incomes.

Relationship of Purchases to Incomes

Observations of the 889 families were cross-tabulated, with per capita income serving as a control, to determine the effect of incomes

TABLE 2—Relationship of quantities of eggs bought and incomes to prices paid for eggs, 1955-58, M.S.U. consumer panel

Price range	Number of family observations	Average price per dozen	Dozen eggs per 100 meals at home	Average annual per capita income
(cents)	(number)	(dollars)	(dozen)	(dollars)
39 or less	32	.36	2.3	1680
40-44	112	.42	2.2	1780
45-49	223	.47	2.3	1820
50-54	340	.52	2.3	2050
55-59	156	.56	2.3	2300
60 or over	26	.62	2.1	2670

on egg purchases. There appeared to be a slight tendency for more eggs to be purchased as incomes increased. (This is shown in Table 3.) However, it should be noted that the average size of family was smaller in the higher income brackets. Since incomes and family size are highly intercorrelated, it is difficult to state which is the real cause of increase in purchases. Table 3 shows that the average price paid rises with higher incomes.

Relationship of Purchases to Family Size

Among the 889 family observations, there was a range in size from one to 11 persons. Data were tabulated to determine how family size may have affected purchases of eggs (Table 4). There appeared to be

TABLE 3—Relationship of quantity of eggs bought, prices paid, and family size to per capital income, 1955-58, M.S.U. consumer panel

Annual per capita income	Number of family observations	Average annual per capita incomes	Average price paid per dozen	Average number of persons per family	Dozen eggs bought per 100 meals at home
(dollars)	(number)	(dollars)	(dollars)	(number)	(dozen)
990 and under	121	770	.49	4.2	2.2
1000—1990	424	1460	.50	3.4	2.2
2000—2990	192	2440	.50	2.6	2.4
3000—3990	99	3420	.52	2.1	2.5
4000 and over	53	5040	.53	2.0	2.3

a tendency for purchases to decline as family size exceeded three persons. As indicated previously, however, per capita incomes also tended to decline as family size increased.

The "Number of Persons" shown in Table 4 refers to the average size of family for the year. A portion of a person would be indicated if the number in the family changed during the year. This happens quite frequently and is occasioned by children coming home from college, parents coming for extended visits, and other reasons.

TABLE 4—Relationship of quantity of eggs bought and per capita incomes to family size, 1955-58, M.S.U. consumer panel

Number of persons	Number of family observations	Average number of persons per family	Average annual per capita income	Dozen eggs bought per 100 meals at home
(number)	(number)	(number)	(dollars)	(dozen)
1.99 or less.....	105	1.1	2520	2.4
2.00—2.99.....	313	2.1	2420	2.5
3.00—3.99.....	147	3.2	2080	2.4
4.00—4.99.....	203	4.1	1550	2.0
5.00—5.99.....	81	5.1	1260	2.1
6.00 and over.....	40	7.1	1030	1.5

Effect of Homemaker Working Away from Home

Among the 235 families in 1958 who sent in 50 or more diaries, 33 had homemakers working away from home. Apparently, this had little effect upon egg consumption. Among the 33 the average quantity of eggs purchased per 100 meals at home was 2.2 dozens, while among the other 202 families, the figure was 2.3 dozens.

Factors Associated with Different Levels of Purchases

The 889 family observations for the 1955-58 period were tabulated with control on dozens of eggs purchased per 100 meals at home. From this, factors associated with different rates of purchases could be determined (Table 5). On the basis of the evidence in this table, one could not describe the socio-economic characteristics of a group of families merely by knowing their egg consumption rates. Incomes, prices paid, or education of homemakers appears to have little relationship to egg consumption. Family composition and age of home-

TABLE 5—Relationship of various socio-economic characteristics of families to purchases of eggs per 100 meals at home, 1955-58, M.S.U. consumer panel

Purchases of eggs per 100 meals at home	Number of family observations	Average number of dozens per 100 meals at home	Average annual per capita income	Average price per dozen	Number of persons 16 years of age or less	Number of persons 17 to 45 years of age	Number of persons 46 years of age or more	Average age of homemaker	Average education of homemaker	Average dozen eggs bought per person per year
(dozen)	(number)	(dozen)	(dollars)	(dollars)	(number)	(number)	(number)	(years)	(years)	(dozen)
.49 or less.....	18	0.4	2050	.52	0.2	0.3	1.4	59	11	4.0
.50— .99.....	79	0.8	1850	.50	1.1	1.2	0.9	47	11	8.4
1.00—1.49.....	148	1.3	1950	.50	1.2	1.1	1.0	49	12	13.4
1.50—1.99.....	175	1.7	1910	.50	1.4	1.4	0.8	44	12	18.1
2.00—2.99.....	275	2.4	2010	.50	1.0	1.1	1.1	47	12	25.5
3.00 and over.....	194	4.0	2210	.50	0.5	0.7	1.3	51	11	42.5

maker, however, seemed associated. Among those who consumed fewer eggs, the homemaker was somewhat older than others. In line with this, there were fewer persons under 46 years of age in the family. This is not conclusive evidence, however, because those who consumed the most eggs were not greatly different in family composition than those who consumed the least.

THE EFFECT OF PREHARVEST FOLIAR SPRAYS OF GIBBERELLIN ON YIELD AND STORAGE BREAKDOWN OF CELERY

By M. J. BUKOVAC, S. H. WITTWER and J. A. COOK
DEPARTMENT OF HORTICULTURE

PRONOUNCED INCREASES in petiole length and fresh weight of field grown celery following treatment with gibberellin were first reported by Bukovac and Wittwer (1956). Their results were subsequently confirmed by Kline, (1958), Takatori *et al.*, (1959), and Tiessen, (1959). Promising growth responses were obtained in celery when 3 to 15 grams of gibberellin were applied per acre two to four weeks before anticipated harvest and when temperatures were too low for optimum growth (Takatori, *et al.*, 1959 and Wittwer and Bukovac, 1957). Conversely, celery plants treated with gibberellin before field transplanting or shortly thereafter elongated excessively, subsequent heart development was poor, premature seedstalk elongation was often induced, and yields were greatly depressed (Wittwer and Bukovac, 1957). Further effects of single and multiple preharvest foliar sprays on yield and storage breakdown are reported.

EXPERIMENTAL PROCEDURE

Plantings of celery were grown during the 1958 and the 1959 season at the Muck Experimental Farm, near East Lansing, Michigan. Randomized block designs with two varieties and several gibberellin treatments were utilized during each growing season. The varieties Utah 10-B and Utah 52-70 H were planted in 1958, and each plot consisted of a single row of 20 plants, spaced 6 inches apart in 32-inch rows. For the 1959 planting Utah 10-B was again used along with Cornell 19. Three adjacent 20-plant rows with the same spacing as in the previous season constituted a plot. Treatments were replicated

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four times in both seasons. Plants were transplanted into the field in late June of each growing season. In both seasons harvest occurred in mid-September.

The two plantings were grown according to accepted commercial practices for high productivity. Foliar sprays (water solution of the potassium salt of gibberellin A_3) were applied according to schedules outlined in Table 1 for 1958 and Table 2 for 1959. Rates of 50 and 100 p.p.m. were equivalent to 3.5 and 7.0 gm. per acre, respectively. Ten stalks were harvested from the central portion of each row in 1958 and 9 plants from each of the 3 rows that constituted a plot in 1959. The non-trimmed and trimmed weights were then determined, along with the average lengths of the second outer petioles for the stalks harvested from each plot.

Ten representative stalks of the 27 cut from each treatment in the 1959 planting were placed in a crate lined with a non-sealed polyethylene crate liner (1.5 mil thickness) and stored at 33 to 34° F. Replications and treatments in the field design were utilized in the storage studies. After 60 days the celery was inspected for storage breakdown. The stalks were cut in cross-section 4 inches above the base and the petioles graded for pithiness and browning.

In the respiration studies, non-gibberellin treated, 4-stalk samples of each variety (Utah 10-B and Cornell 19), and comparable samples of each variety which had been sprayed (3 weeks before harvest) with 100 p.p.m. of gibberellin were placed in 5-gallon, wide-mouth glass jars at 32° F. Each treatment was replicated twice. The evolution of the CO_2 of the newly harvested celery during a five-day period was determined at approximately 24-hour intervals using the procedure outlined by Claypool and Keefer (1942).

RESULTS

1958 Planting: A multiple gibberellin spray of 50 p.p.m. two and three weeks before harvest and a single spray of 50 or 100 p.p.m. four weeks before harvest, significantly increased the yields of trimmed Utah 10-B celery (Table 1) compared to controls. Yield differences in Utah 52-70 H were not significant. Trim-out percentages were not changed appreciably in either variety by the treatment imposed.

The most pronounced effect of gibberellin was on petiole length (Table 1). All gibberellin treatments significantly increased petiole length on Utah 10-B. However, with Utah 52-70 H, a taller variety

TABLE 1—Effect of gibberellin on yield (trimmed and non-trimmed weights) and petiole length of Utah 10-B and Utah 52-70 H celery—1958 planting

Gibberellin treatment		Utah 10-B			Utah 52-70 H		
		Yield			Yield		
Concentration	Weeks before harvest	Non-trimmed weight (*a*)	Trimmed weight (*a*)	Petiole length(*b*)	Non-trimmed weight (*a*)	Trimmed weight (*a*)	Petiole length(*b*)
(p.p.m.)		(lb.)	(lb.)	(in.)	(lb.)	(lb.)	(in.)
0 (no treatment)		23.8	15.6	8.7	27.2	14.6	10.3
50	2	25.2	16.1	9.2	28.9	15.0	10.8
	3	27.1	17.4	10.7	28.2	14.8	11.5
	4	27.1	17.6	10.6	28.6	15.3	11.9
	2 and 3	27.5	17.5	10.8	30.8	15.8	10.9
	3 and 4	——	——	——	28.5	15.3	11.7
100	2	25.3	16.1	9.8	27.3	14.5	10.7
	3	27.3	17.9	10.6	27.4	14.7	11.4
	4	28.3	18.0	10.8	29.5	15.2	11.8
	2 and 3	——	——	——	26.5	14.1	11.1
	3 and 4	——	——	——	30.7	16.4	12.5
L.S.D. P=.05		3.6	1.9	0.4	N.S.	N.S.	1.1

(*a*) Total weight of 10 stalks.
(*b*) Average length of second outer petiole.

than Utah 10-B, the differences were less striking. Petioles per stalk were not significantly altered. Increased stem elongation, seedstalk formation, and twisting of petioles were noted with 100 p.p.m. applied four weeks before harvest and following all multiple applications of 100 p.p.m.

1959 Planting: Foliar sprays of gibberellin (100 p.p.m.) two or three weeks before harvest significantly increased the fresh trimmed weight of Cornell 19, but not of Utah 10-B (Table 2). Petiole length was increased 9 to15 percent in both varieties.

The effects of gibberellin on pithiness and browning of petioles after 60 days of storage are shown in Table 3 and Figure 1. Pithiness and browning were both greater on the gibberellin treated celery. The early stages of petiole breakdown appeared as well defined white areas in the outermost petioles. In more advanced stages vacuolation occurred, the white areas turned brown, and tissues completely deteriorated (Fig. 1).

TABLE 2—Effect of gibberellin on yield and petiole length of Cornell 19 and Utah 10-B celery—1959 planting

Treatment	Cornell 19		Utah 10-B	
	Yield(*a*)	Petiole length(*b*)	Yield(*a*)	Petiole length(*b*)
	(lb.)	(in.)	(lb.)	(in.)
Control	34.8	9.0	42.8	8.8
100 p.p.m. 2 weeks before harvest	41.0	9.8	43.8	10.0
100 p.p.m. 3 weeks before harvest	40.2	10.2	44.2	10.1
L.S.D. P = .05	4.2	0.8	N.S.	0.3

(*a*) Total weight of 27 trimmed stalks.
(*b*) Average length of second outer petiole.

The accumulative amounts of CO_2 (milligrams of CO_2 per kilogram) respired by gibberellin- and non-treated celery are given in Fig. 2. There was significantly less respiratory activity in gibberellin-treated

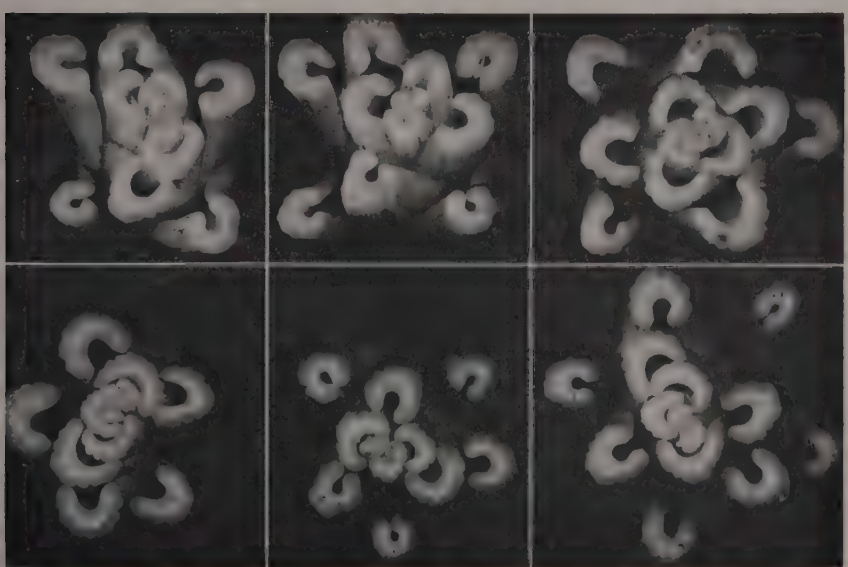

Fig. 1. Petiole cross-sections 4 inches above the base of Cornell 19 (top) and Utah 10-B (bottom) celery stalks showing the effect of gibberellin on storage breakdown. Left to right, control, 100 p.p.m. of gibberellin applied 2 weeks before harvest, and 100 p.p.m. of gibberellin applied 3 weeks before harvest.

TABLE 3—Effect of gibberellin on storage breakdown of petioles of Cornell 19 and Utah 10-B celery stored in polyethylene lined crates for 60 days at 33-34°F. (Data expressed as percent of total petioles).

Treatments	Cornell 19		Utah 10-B	
	Pithy	Browning	Pithy	Browning
Control (no treatment)	30.1	4.9	26.0	2.4
100 p.p.m. 2 weeks before harvest	40.2	33.9	34.7	6.6
100 p.p.m. 3 weeks before harvest	45.8	27.1	40.8	15.8
L.S.D. P=.05	4.7	10.3	12.1	11.4
P=.01	6.5	14.9	N.S.	N.S.

Utah 10-B celery than in non-treated controls. Likewise, less CO_2 was respired by Cornell 19 treated with gibberellin, but the differences were not statistically significant (Fig. 2).

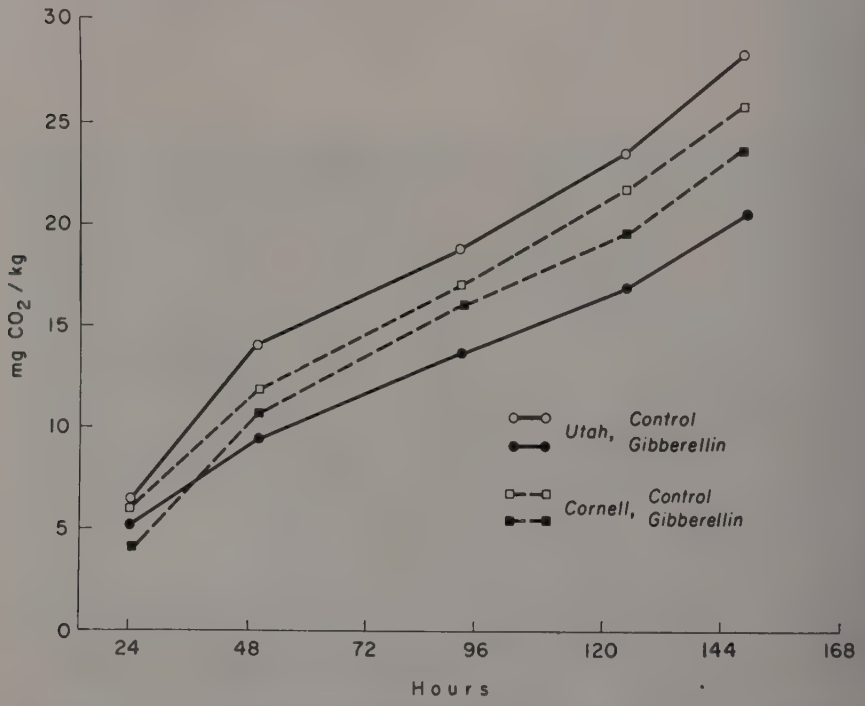

Fig. 2. The accumulative milligrams of CO_2 (mg/kg) respired by freshly harvested gibberellin-treated and non-treated Cornell 19 and Utah 10-B celery during a 5-day storage period at 32°F. Gibberellin-treated celery was sprayed with 100 p.p.m. 3 weeks before harvest.

DISCUSSION

Pre-harvest foliar applications of gibberellin significantly increased the petiole length of field grown celery. Fresh weight differences, however, were not consistent. The variety Utah 10-B was grown both seasons and similarly treated with gibberellin, yet significant yield differences were recorded only in 1958. A possible explanation for this differential response may be found in the pre-harvest temperature differences during the two growing seasons. In 1958 the mean temperature from August 15 to September 10 was 66° F.; whereas, in 1959 the mean temperature during the same period was 74° F. These results confirm previous observations that growth responses of celery as well as other crops following treatment with gibberellin are most pronounced at temperatures which are sub-optimal for growth (Takatori *et al.*, 1959, and Wittwer and Bukovac, 1957).

The increased incidence of pithiness and browning of petioles of gibberellin-treated celery in storage may be associated with larger and thinner-walled cells formed in the longer petioles. The induced pithiness was similar to that frequently associated with overmaturity. There is now considerable evidence that the optimum harvest period for celery is advanced and considerably narrowed following treatment with gibberellin.

The lower respiration rate of celery treated with gibberellin is difficult to reconcile with the greater incidence of petiole breakdown. Lower respiration rates similarly have been reported for gibberellin-treated bean internode tissue (Weller *et al.*, 1957) when the results were expressed on a fresh weight basis. Higher respiratory rates, however, occurred for both beans (Weller *et al.*, 1957, and Kato, 1956) and peas (Kato, 1956) for the entire internode.

SUMMARY AND CONCLUSIONS

Single and multiple pre-harvest foliar sprays of gibberellin (50 and 100 p.p.m.) applied to field grown celery during two growing seasons consistently increased petiole length by 4 to 24 percent as compared to non-treated controls. Increases in fresh weight of trimmed stalks, however, were less consistent and dependent upon variety and season.

Pre-harvest treatment with gibberellin significantly increased the amount of pithiness and browning of petioles of celery stalks stored in polyethylene lined crates at 33 to 34° F. for 60 days. Less CO_2 (mg

CO_2/kg) was evolved from gibberellin treated (100 p.p.m. three weeks before harvest) celery stalks stored at 32° F. than from those which were not treated.

Gibberellin stimulated petiole elongation and often increased the fresh weight of marketable stalks of field-grown celery. However, certain deleterious effects, including twisting of petioles, a narrower harvest period, seedstalk formation, and rapid breakdown in storage, appear to be directly related to treatment with gibberellin and may outweigh any benefits derived from an increase in petiole length or fresh weight. When celery is grown in areas or during the season of the year where sub-optimum temperatures prevail during maturation of the crop, maximum effect on petiole elongation and fresh weight may be obtained. Additional studies should be conducted before definite recommendations are made for the use of gibberellin as a preharvest spray on fresh market celery in Michigan.

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QUALITY AND CONDITION CHANGES OF McINTOSH APPLES STORED IN CONTROLLED ATMOSPHERES

By G. D. BLANPIED[1] and D. H. DEWEY

Department of Horticulture

Controlled atmosphere storage McIntosh apples are usually marketed after the regular cold-storage supply is depleted. However, there is occasionally a desire to market them earlier. CA storage will prolong the life of McIntosh[2], but little is known about the quality of the fruit during the earlier portion of the marketing season. Studies were made of quality and condition changes of this variety stored in regular air and in controlled atmospheres during the 1957-58 and 1958-59 seasons.

The results should be useful to apple handlers in determining when quality differences would justify earlier openings of CA rooms, and in anticipating normal changes in fruit condition once apples have been removed from storage.

Apples used for study were harvested from trees in commercial blocks of the Sparta and Belding fruit areas and on the Michigan State University experimental farm at East Lansing. Samples were stored in air at 32-33° F. (Check) and in an atmosphere of 3 percent oxygen and 5 percent carbon dioxide at 38° F. (CA) during the 1957-58 and 1958-59 seasons.

Flesh Firmness

Changes in flesh firmness of the apples at intervals during the 1957-58 storage period are shown in Fig. 1—Part A. During the first half of the storage season, the check apples were firmer than the CA

[1]Present address: Pomology Department, Cornell University, Ithaca, New York.

[2]Van Doren, A. (1939). Physiological studies with McIntosh apples in modified atmosphere cold storage. Proc. Amer. Soc. Hort. Sci. 37: 453-458.
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apples. At the mid-point of the storage period, however, firmness of the CA apples levelled off slightly above 9.0 pounds while the checks continued to decline in pressure to 8.5 pounds before levelling off.

A similar trend of flesh softening was observed for the 1958-59 storage season (Fig. 2). The CA fruit, however, was firmer than the check fruit at three months. No information on the rate of flesh softening between harvest and three months was obtained.

Changes in flesh firmness of CA and check apples after seven days at 75° F., following removal from storage in the 1957-58 season, are shown in Part B of Fig. 1. The pattern noted for softening after seven

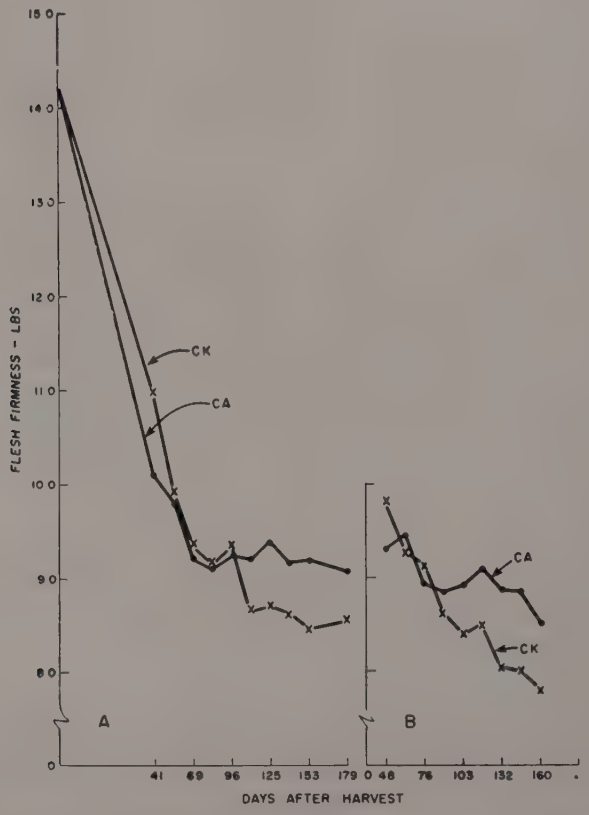

Fig. 1. Flesh firmness of McIntosh apples upon removal from controlled atmosphere (CA) and regular storage (Ck) during the 1957-58 season. A, after one day at 75° F.; B, after seven days at 75° F.

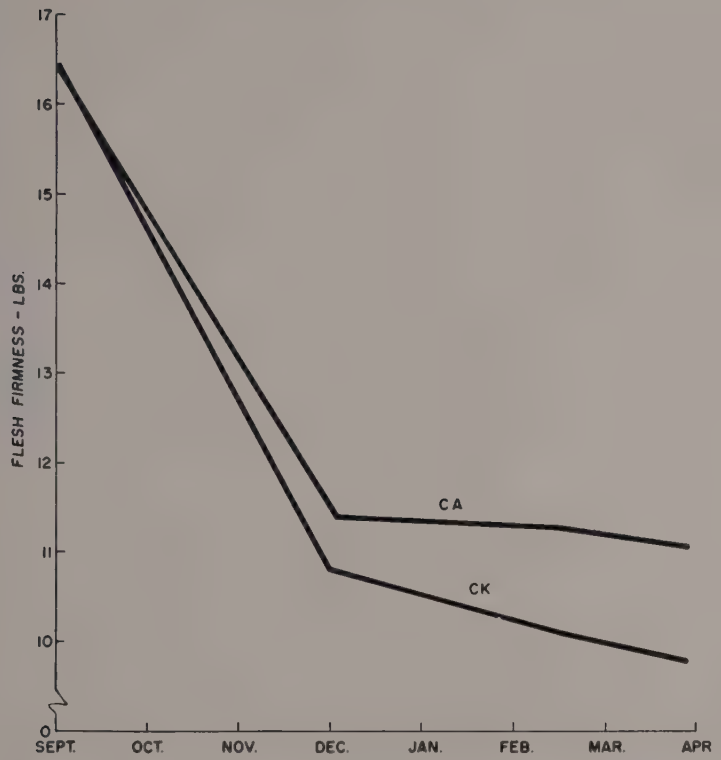

Fig. 2. Flesh firmness of McIntosh apples removed from controlled atmosphere (CA) and regular (Ck) storages in early December, February and late March (1958-59 season).

days for both CA and check apples was similar to the pattern for the various times of removal from storage. The amount of flesh softening at 75° F. was similar, being 0.4 pounds for the CA apples and 0.6 pounds for the check apples.

Apples obtained from four orchards were removed from storages in March, 1959. Samples were tested for firmness after one and seven days at 75° F. and after eight weeks of additional storage in regular air at 33° F. (Table 1). The CA apples were firmer than the check apples at all sampling dates. Average softening during six days at 75° F. was similar for the two storage treatments; however, softening was erratic according to orchard source of the fruit. It ranged from 0.2 to 1.2 pounds for CA fruit, and from 0.4 to 1.3 pounds for check

fruit. The CA apples softened 0.4 pounds during the additional eight weeks of storage at 33° F. in regular air while the check apples had an average loss of 0.1.

The present study shows that apples stored in CA to January and later had firmer flesh than apples stored for the same periods in regular air. The rapid softening noted for the CA apples in the early period of storage may have resulted from the high storage temperature, and in particular, during the initial two-week period required to reduce the oxygen level to 3 percent. Temperatures below 38° F. are not used in CA storage of McIntosh apples because they tend to increase the incidence of carbon dioxide injury and brown core.[3]

Since softening rates of the fruit differed only during storage, any advantage in flesh firmness expected for CA apples over apples from regular storage must be gained prior to removing them from the sealed storage.

TABLE 1—Flesh firmness(a) of McIntosh apples from four orchards stored in controlled atmospheres (CA) and regular air (Ck) to March.

Orchard	Before storage	Storage plus 1 day at 75° F.		Storage plus 7 days at 75° F.		Loss during 6 days at 75° F.		Storage plus 8 weeks at 33° F.	
		Ck	CA	Ck	CA	Ck	CA	Ck	CA
A	16.5	8.8	11.1	8.4	9.9	0.4	1.2	8.9	9.9
B	14.9	8.3	9.5	7.0	8.6	1.3	0.9	8.2	9.2
C	15.1	8.6	9.6	7.5	8.6	1.1	1.0	8.2	9.2
D	16.0	9.1	9.3	8.1	9.1	1.0	0.2	9.0	9.6
Average.....	15.6	8.7	9.9	7.8	9.1	1.0	0.8	8.6	9.5

(a) Measured in pounds by a Magness-Taylor tester with a $\frac{7}{16}$ inch tip.

Panel Evaluations

A panel of five to six persons, experienced in evaluating fruit quality, judged appearance, texture, flavor and ripeness characteristics of apples removed from CA and regular storage at two-week intervals during the 1957-58 season. High quality was given a rating value of 5; poor quality, namely, unmarketable appearance, mealy texture, lacking in flavor and overripe, was rated 0, while gradations of intermediate quality were rated 1, 2, 3 or 4.

The panel was unable to note quality differences consistently

[3]Op. cit., footnote 2.

until the mid-point of the storage season (Fig. 3). There was little subsequent decline in quality of the CA fruit while check fruit continued to deteriorate through the remainder of the storage season. The differences due to storage treatment at one and seven days after removal from storage were similar. At the end of the storage season, the CA fruit was ripe in taste and appearance, melting in texture, and sweet in flavor.

Panel ratings for apples from the four orchards upon storage to March are given in Table 2. Although apples from a given orchard consistently kept better in controlled atmospheres than in regular air, the degree of superiority of the CA apples was variable. For instance, the panel gave a 0.6 point difference for CA and check apples from Orchard C, and 1.4 points difference for the apples of Orchard B. Also, the check apples of Orchard D were rated higher in quality than

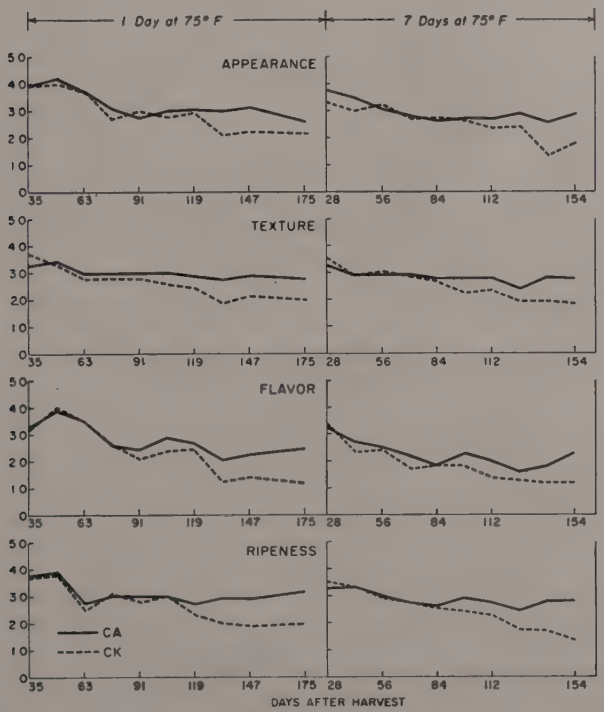

Fig. 3. Quality ratings (0 to 5.0) of McIntosh apples after removal from controlled atmosphere (CA) and regular (Ck) storages during the 1957-58 season.

CA apples from Orchard C. It is apparent that factors other than storage method are often important in determining the final quality of stored fruit.

TABLE 2—Quality ratings of McIntosh apples after four days at 75° F. following storage to April in controlled atmospheres (CA) and regular air (Ck)

Orchard	Texture			Flavor			Ripeness			Average		
	CA	Ck	Diff.	CA	Ck	Diff.	CA	Ck	Diff.	CA	Ck	Diff.
A	3.2	2.6	0.6	3.4	2.9	0.5	3.8	3.0	0.8	3.5	2.8	0.7
B	3.0	1.8	1.2	3.5	1.8	1.7	3.3	2.1	1.2	3.3	1.9	1.4
C	2.1	1.5	0.6	1.8	1.2	0.6	2.1	1.4	0.7	2.0	1.4	0.6
D	3.0	2.6	0.4	3.1	1.9	1.2	2.8	2.4	0.4	3.0	2.3	0.7
Average.....	2.8	2.1	0.7	3.0	2.0	1.0	3.0	2.2	0.8	3.0	2.1	0.9

Skin Toughness

Puncture tests of epidermal tissues of apples confirmed the general observation that CA apples have a tougher skin than apples stored by regular means. Pressure values required to break the skin of apples following storage to March are shown in Table 3. In all instances, the skin of the CA apples was significantly resistant to puncture. Continued storage at 33° F. in regular air for eight weeks tended to reduce resistance of the CA apple skin.

Other Condition Factors

Data concerning other condition factors for apples from the four orchards are given in Table 4. Soluble solid contents of the extracted juice of the apples were not affected by storage treatment. There was a greater amount of skin shrivel of the check apples than on CA apples. This difference was probably due to the lower relative humidity in regular storage. No senescent core browning was found after a holding period of one week at 75° F. in the CA apples, while 20 to 95 percent of the check apples were affected. After two weeks, 16.7 percent of the CA apples showed traces of senescent core browning and 94.7 percent of the check apples were severely affected. The percent of CA and check apples with storage scald increased slightly upon holding so that at two weeks, 97.5 percent of the check apples were

TABLE 3—Skin toughness of McIntosh apples from four orchards after storage to March in controlled atmospheres (CA) and regular air (Ck)

Storage treatment and holding period	Orchard A	Orchard B	Orchard C	Orchard D	Average
Magness-Taylor pressure tester: pounds to break the peeled skin with 5/16" tip					
CA—4 days at 75° F.....	7.2	5.4	5.3	5.4	5.8**
Ck—4 days at 75° F.....	3.9	4.9	4.0	4.5	4.4
Chatillon dynamometer: grams to break intact skin with 0.8 mm. tip					
CA—4 days at 75° F.....	273	263	263	275	269**
Ck—4 days at 75° F.....	208	225	220	239	223
CA—8 weeks at 33° F. plus 1 day at 75° F.....	242	240	229	250	240*
Ck—8 weeks at 33° F. plus 1 day at 75° F.....	207	212	210	225	215

**Significant at 1% level.
*Significant at 5% level.

TABLE 4—Condition of McIntosh apples from four orchards after one and two weeks at 75° F. following storage to March in controlled atmospheres (CA) and regular air (Ck)

Orchard	Storage treatment	Soluble solids (a)	Skin shrivel(b)	Senescent core browning			Storage scald		Mealy breakdown
		1 week (%)	1 week (rating)	1 week (%)	2 weeks (%)	(amount)	1 week (%)	2 weeks (%)	2 weeks (%)
A	CA	12.0	Slight	0.0	8.8	Trace	0.0	0.0	0.0
	Ck	12.0	Moderate	25.0	77.4	Moderate	74.3	95.2	22.6
B	CA	10.5	Slight	0.0	30.4	Trace	2.9	2.2	0.0
	Ck	10.5	Mod-Severe	95.0	100.0	Severe	91.4	100.0	10.9
C	CA	11.5	Slight	0.0	16.7	Trace	17.1	27.0	0.0
	Ck	11.0	Slight	20.0	98.2	Severe	62.9	94.6	37.5
D	CA	11.3	Slight	0.0	10.7	Trace	5.7	3.6	0.0
	Ck	11.3	Moderate	95.0	98.1	Severe	97.1	100.0	5.6
Average	CA	11.3	Slight	0.0	16.7	Trace	6.4	8.2	0.0
	Ck	11.2	Moderate	58.8	94.7	Severe	81.4	97.5	19.2

(a) Soluble solids at harvest: A—12.5%; B—11.5%; C—12.0%; D—12.0%.
(b) Skin shrivel when apple was pressed between the thumb and forefinger.

affected while only 8.2 percent of the CA apples were scalded. No mealy breakdown was observed at this time in CA apples; whereas, 5.6 to 37.5 percent of the check apples showed this disorder.

SUMMARY AND CONCLUSIONS

McIntosh apples stored in controlled atmospheres of 5 percent carbon dioxide and 3 percent oxygen at 38° F. and in regular cold storage at 33° F. were observed for quality and condition changes during and following storage.

Quality differences according to method of storage were not evident until the fruit had been stored for approximately 100 days. The superiority of the CA apples in respect to flesh firmness, texture, flavor, and degree of ripening became more apparent as the storage period lengthened.

Loss of quality after removal from storage was similar for apples from both storage conditions at each removal date. The duration of market or shelf-life of the apples, therefore, was primarily dependent upon the extent of the changes which had already occurred during storage. Pre-storage factors also were important since fruit from different orchards varied in final quality.

Development of senescent core browning, storage scald and mealy breakdown was retarded by controlled atmosphere storage.

Puncture tests showed that the skin of CA apples is tougher than that of apples from ordinary cold storage.

MECHANIZING THE HARVEST OF PLUMS[1] [2]

By H. P. GASTON,[3] S. L. HEDDEN,[4] and J. H. LEVIN[4]

MANY MICHIGAN FRUIT GROWERS produce plums to diversify their operations. During each of the last three years, more than 7,000 tons of this fruit have been grown in the State. The farm value of each of these crops has exceeded $600,000.

Pickers are usually paid from 35 to 75 cents per bushel to harvest plums, the amount depending on the variety, size, crop and availability of labor.

Mechanized machines have been developed to harvest red tart cherries[5] and inasmuch as the two fruits grow in the same areas but mature at different times, it was decided to find out if the recently developed cherry harvesting equipment could be used to advantage in harvesting plums. Many Michigan cherry growers no doubt will provide themselves with these machines in the near future, and if they can be used in harvesting both cherries and plums, overhead costs will be materially reduced.

This study was undertaken to obtain answers to the following questions:

1) Can the machines developed for harvesting cherries be used successfully in harvesting plums?
2) Will the use of this equipment reduce plum harvesting costs?
3) Will machine picked plums meet grade requirements?

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[1]Based on work carried out jointly by the fruit and vegetable harvesting section, harvesting and farm processing branch, agricultural engineering research division, U.S.D.A.; and departments of horticulture and agricultural engineering, Mich. State Univ., East Lansing, Mich.

[2]Acknowledgments: The authors wish to express their appreciation to L. G. Howlett, Keeler, and to Circle Three Orchard, Fremont, Michigan, in whose orchards the harvesting trials were conducted.

Credit is also due Gerber Products Co., Fremont, Michigan, who processed the machine picked fruit and were helpful in other ways.

[3]Department of horticulture.

[4]Agricultural engineers, agricultural engineering research division, A.R.S., U.S.D.A.

[5]This equipment is described in detail in Article 42-60, "Mechanizing the Harvest of Red Tart Cherries," of this issue of the Quarterly Bulletin.

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HOW THE STUDY WAS MADE

The machines developed for harvesting cherries were used in harvesting plums during both the 1958 and 1959 seasons. Time, motion, and cost studies were made of operations in which 8,760 pounds of Stanley Prune plums were harvested from 39 trees. Quality evaluations were made in the orchards and at the processing plant where the mechanically harvested plums were packed.

Equipment used in the trials included a tree-shaker (Fig. 1) to separate plums from the tree and catching devices to collect the separated fruit. The tractor-mounted, hydraulically-activated boom shaker, with a claw (clamp) at the end, was maneuvered so that the claw could be "attached" to scaffold branches. Once the boom was in position, the operator could shake the limb by activating the device. The separated fruit was caught in canvas-covered metal collecting units positioned under the tree being harvested. The plums were transferred from the collecting units to bulk boxes by means of half-bushel baskets (Fig. 2). They were moved from the orchard to the processing plant in bulk boxes.

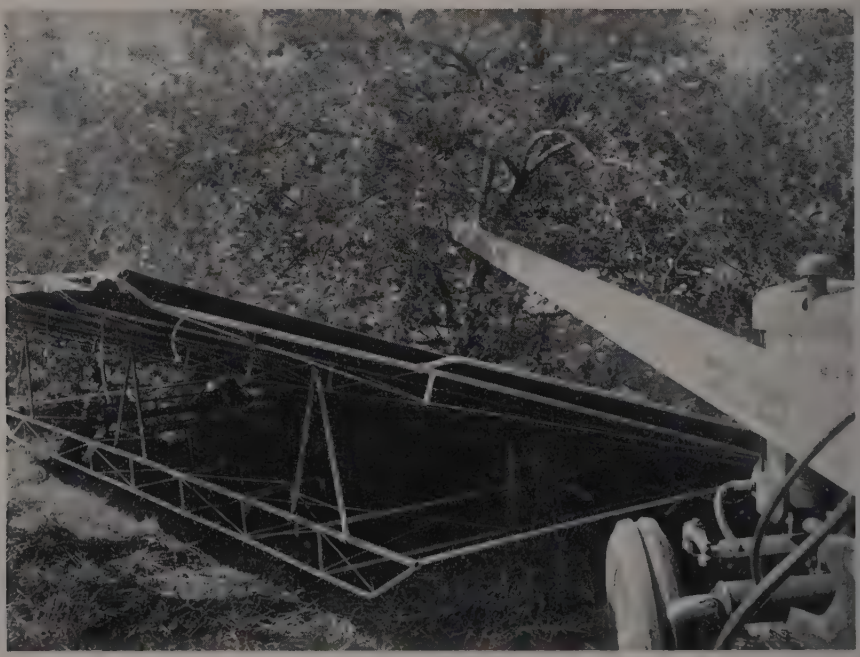

Fig. 1. This picture shows how the boom shaker and collecting unit are used in harvesting plums.

Fig. 2. Plums which have been harvested mechanically are being transferred from collecting units to baskets.

RESULTS

Fruit Recovery

The boom-shaker used in the trials separated from 93 to 99 percent of the plums. The exact figures depended on maturity of fruit and the conformation of the tree. The average amount of fruit separated from the 39 Stanley Prune plum trees included in the trials was 95.3 percent. Most of the acceptable plums remaining on the tree after mechanical shaking could be separated with a hand-held pole shaker. Whether or not it pays to employ the labor necessary to do this work depends on circumstances, the percentage of plums separated by the machine, the conformation of the tree, etc.

Rate of Harvest

In the 1959 trials, trees were harvested at an average rate of 10.1 trees per hour. More than 80 trees could be harvested in an 8-hour day. The average yield of fruit was 5.1 bushels per tree. The amount of fruit on individual trees did not materially affect the rate at which they could be harvested.

Labor

The crew consisted of a shaker operator, tractor-lift operator who handled the bulk boxes, and three other workers who moved the collecting units from tree to tree, put the plums in baskets and emptied these into the bulk boxes "spotted" nearby.

Costs

Each member of the five-man crew was paid $1.20 per hour. Labor costs were $6 per hour. The per-bushel costs were approximately 12 cents ($6 divided by 51 bushels). When compared to the per bushel cost of 35 cents normally paid for handpicking Stanley Prunes, savings on labor is about 23 cents per bushel.

The equipment enabled the five-man crew to harvest about 51 bushels per hour or 408 bushels in an 8-hour day. The per-day savings, therefore, were more than $90. This means, other things being equal, a plum grower whose average yield was 5.1 bushels per tree, could afford to pay up to $90 for the use of mechanical harvesting equipment. (Lower yield would mean proportionately smaller savings.)

If the grower owns cherry harvesting equipment which costs from $3,000 to $4,000 and uses it to harvest plums, savings will help pay overhead equipment costs. If he does not own the machines, he may be able to lease them from other cherry growers living nearby. Growers who do not own and cannot lease the equipment may be able to have their plums picked on a custom basis.

Quality

The mechanically harvested fruit was checked for bruises, stems, leaves and twigs. On the average, 3.1 percent of the plums were severely bruised. Minor bruises were found on an additional 4.2 percent.

From 3 to 14 percent came off with stems attached. The exact amount varied from tree to tree depending on degree of maturity of the fruit and structure of the tree.

The leaves and twigs which came off with the plums accounted for 2.7 percent of total weight.

The quality of the mechanically harvested plums was comparable to that of the hand picked fruit being received at the processing plant. The cooperating processor stated that leaves, twigs and stems could be separated during the processing operation without great difficulty and

bruised fruit would not present a serious problem if it could be processed without too much delay. The packer further stated that he would be willing to accept mechanically harvested plums provided they graded out as well as experimental lots processed during the 1958 and 1959 seasons.

In addition to the 39 Stanley Prune plum trees on which the machines were used, the equipment was employed in harvesting several Damson plum trees. It was found that when the machines were used in harvesting this variety, approximately 5 percent of the separated fruit came off with spurs attached. It was feared that separating so many fruit spurs might reduce the amount of fruit borne in succeeding years. After a few trees had been harvested, attempts to use mechanical equipment on this variety were discontinued.

The trials indicated that effectiveness of mechanical picking is influenced primarily by variety, size and shape of the tree, the number of scaffold limbs, terrain, size of the crop, and maturity of fruit. Growers should realize that results achieved will be affected by these and other variables.[6]

CONCLUSIONS

Under conditions existing in many Michigan Stanley Prune plum orchards:

1) Plums can be harvested successfully with equipment previously developed for harvesting cherries.
2) Plum harvesting costs can be reduced when the equipment is used for harvesting both cherries and plums.
3) When care and well-designed equipment is used, mechanically harvested plums normally meet acceptable grade standards.

[6]Variables which affect results achieved in picking cherries with machines are discussed in the publication referred to in footnote 5.

THE EFFECT OF GIBBERELLIN ON THE MINERAL COMPOSITION OF YEAR-OLD MONTMORENCY CHERRY TREES

By L. N. LEWIS and J. HULL, Jr.[1]

DEPARTMENT OF HORTICULTURE

MANY GROWTH REGULATING COMPOUNDS alter the mineral composition of plants. Rebstock, *et al* (1954) found that 2, 4-dichlorophenoxyacetic acid increased the phosphorus content of bean stem tissue. Increases in calcium, phosphorus and nitrogen have been reported following treatment with alpha napthaleneacetamide (Hamner, 1942), and potassium, magnesium, boron, phosphorus, copper, iron and aluminum in response to indoleacetic acid (Brunstetter *et al*, 1948). Naylor and David (1950) found that maleic hydrazide often induced phosphorus deficiency symptoms. Wittwer, Bukovac, and Grigsby (1957), however, found that gibberellin did not significantly alter the mineral composition of Kentucky bluegrass. The object of this experiment was to see what effect gibberellin would have on the nutrient composition of leaves of Montmorency cherry trees.

The growth responses resulting from gibberellin treatments have been reported in a previous paper (Hull and Lewis 1959). An increase in total linear growth, trunk diameter, and fresh and dry weight was observed on trees treated with 1,000 p.p.m. With 500 p.p.m., the trees increased in total linear growth and trunk diameter, while 100 p.p.m. caused only an increase in trunk diameter.

PROCEDURE

In the spring of 1958, one-year-old Montmorency cherry trees were potted in silica sand in 12-inch clay pots and placed in a greenhouse under natural light at a temperature of about 70° F. unless outside weather conditions caused higher temperatures. Nutrients were supplied to the trees through three applications per week of a standard

[1]Department of horticulture, Purdue Univ., Lafayette, Ind.

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solution developed by Hoagland and Arnon (1956), and biweekly washings of the sand with tap water were used to prevent accumulation of salts.

On May 21, 1958 when the terminal buds had formed on the trees, they were randomly divided into four groups consisting of 3 two-tree plots and given foliar sprays of gibberellin[2] at one of four concentrations: 0, 100, 500, or 1,000 p.p.m. The experiment was moved outdoors in June and in August all of the leaves were removed from the trees for analysis. Leaves from each plot were pooled into a single sample, dried, and ground to pass through a "20 mesh" sieve. Nitrogen was determined by the Kjeldahl method; potassium by flame photometry; phosphorus, calcium, magnesium, iron, boron, manganese, and copper were determined spectrographically.

RESULTS AND DISCUSSION

Foliar composition data (Table 1) shows a comparable increase in the nitrogen concentration of the trees treated with 100, 500, or 1,000 p.p.m. of gibberellin. The percentage of calcium decreased about the same in the leaves of trees sprayed with 100, 500, or 1,000 p.p.m. of gibberellin. Boron concentration was lower in the trees treated with 1,000 p.p.m. than in the trees receiving 0, 100, or 500 p.p.m. The percent of phosphorus, potassium, magnesium, manganese, iron, and copper in the leaves was not significantly altered by gibberellin treatment.

[2]The gibberellin used was 0.5 percent oil emulsion, Gibrel, donated by Merck and Co., Rahway, New Jersey.

TABLE 1—Effect of gibberellin on the mineral composition of Montmorency cherry leaves from trees grown in sand culture. Data based on percent dry weight

Element	Gibberellin—p.p.m.			
	0	100	500	1000
N	2.64	2.94**	2.83**	2.87**
P	0.17	0.18	0.19	0.18
K	2.83	2.75	2.76	2.75
Ca	2.72	2.24**	2.19**	2.20**
Mg	0.64	0.59	0.64	0.66
B	0.0045	0.0047	0.0043	0.0036*
Mn	0.0042	0.0038	0.0032	0.0032
Fe	0.0145	0.0164	0.0175	0.0158
Cu	0.0024	0.0024	0.0019	0.0019

**Indicates a difference from the controls significant at the 1 percent level.
*Indicates a difference significant from the controls at the 5 percent level.

SUMMARY

Foliar applications of gibberellin significantly increased the concentration of nitrogen and decreased concentrations of calcium and boron in leaves of year-old Montmorency cherry trees. The percent of phosphorous, potassium, magnesium, manganese, iron, and copper was not altered by gibberellin.

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A STUDY OF THE PHYSICAL AND CHEMICAL PROPERTIES OF MICHIGAN PEPPERMINT OIL[1]

By WINSTON M. LAUGHLIN

PEPPERMINT *(Mentha piperita)* is an important crop on organic soils of Michigan and Indiana. The oil distilled from this herb is composed of various organic compounds.

This report covers a two-year study of peppermint oil obtained from field plots in four Michigan localities. Properties investigated included specific gravity, optical rotation, refractive index, and contents of free esters, total menthol, and menthone. Changes in these properties throughout the seasons and the relationships between menthol and menthone and between menthol and specific optical rotation is discussed.

REVIEW OF LITERATURE

Guenther (1944), Bullis, et al. (1948), Ellis (1945), and Rabak (1916) reported percentages of esters and menthol increased as the growing season progressed. Ellis and Gaylord (1944) observed such an increase in the menthol content. Strazewicz (1928), on the other hand reported a decrease of esters in the oil with maturity, particularly with increased insolation and temperature. Chiris (1925) also found an increase in percentage of menthol with the age of the plant, but found the specific optical rotation value decreased. Bullis, et al. (1948), discovered specific optical rotation of the oil to be higher in earlier and later season samples than in midseason lots. Baldinger (1942) and Rutovskii and Travin (1930) noted that the menthol content of the plant increased during growth, whereas the menthone content decreased. Increase of the percentage of menthol at the expense of the percent of men-

[1]A thesis submitted to the graduate school of Mich. State Univ. in partial fulfillment of the requirements for the degree of doctor of philosophy. The author expresses his appreciation to Dr. Erwin J. Benne and other members of the department of agricultural chemistry who made available laboratory space and equipment for performing the chemical analyses and to Dr. Paul M. Harmer who guided field work conducted. The Beechnut Packing Company provided financial assistance which made this study possible.

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thone led Gordon (1927) and Wood and Osol (1937) to assume that, under the influence of sunlight during plant growth and up to the time of full bloom, menthol is slowly formed from menthone. Bacon, et al. (1923) suggested that menthol is synthesized from menthone which in turn is produced from pulegone.

EXPERIMENTAL

In 1947 and 1948 field plots were established in four localities in Michigan to ascertain the effect of various soil treatments on the growth of peppermint. All plots were handled as nearly as possible as commercial plantings. At harvest the mint was cut, weighed, cured, and steam distilled in a portable still. This still, patterned after a commercial mint type, was designed to operate with steam and water from the boiler and well of a regular grower's still. The herb was distilled for at least 5 minutes after no odor of oil could be detected in steam emitted from a small hole in the top of the tub when the cork was removed. This time varied from one-half to one hour depending on the quantity of steam emitted and condition of the crop. The drier the plants, the shorter the time required. The oil was collected in the customary way in a gravity separator over water. At completion of each distillation, all oil was removed from the separator, together with approximately 2 gallons of water. This was poured in a large separatory funnel and, after a few minutes, the greater portion of water was removed. That which remained (oil, water, and sludge) was taken to the laboratory, filtered, and the remainder of the water removed. After weighing the oil from each plot, a 4-ounce ground glass stoppered bottle, containing 1 teaspoon of anhydrous sodium sulfate, was completely filled with a sample of the oil. These samples were then placed in cold storage at approximately 40° F. temperature until the physico chemical properties were determined.

Methods Used and Determinations Made

Specific Gravity — A 50-gram pycnometer with attached thermometer was used in determining specific gravity at 25°C. (25/25°).

Optical Rotation — Specific optical rotation was obtained at 25° C. by means of a 100 mm. tube and a Franize, Schmidt, and Huensch saccharimeter, using a potassium dichromate solution as a filter for

the light source. (This filter gives a light equivalent to that of a sodium laboratory arc.)

Refractive Index — Determined at 20°C by use of an Abbe refractometer.

Esters — The United States Pharmacopoeia method (1942) was used and esters were calculated as menthyl acetate.

Total Menthol — The U.S.P. procedure and formula (1) for calculating the percent of menthol were employed.

Menthone — The hydroxylamine hydrochloride method, as outlined by Baldinger, (1942) was used.

RESULTS AND DISCUSSION

Table 1 shows that in 1947 and still more in 1948, specific optical rotation and percentage of esters and total mentol increased while the percentage of menthone decreased throughout the harvesting season or with further maturity of the plant.

Also shown were greater changes in these physicochemical constants in 1947 than in 1948. This is undoubtedly a result of the different seasons. Unusually wet and cool conditions prevailed throughout the 1947 growing season while in 1948 it was unusually dry and warm.

A correlation coefficient of −0.971 was found between the percent of menthol and menthone of 239 samples (Fig. 1). This denotes a high degree of relationship between the two properties.

Each value in Table 2 consists of the mean of eight treatments of each of three replications of a set of minor element plots in Clinton County (see Table 3 for treatments). Since the minor elements did not influence these constants, the values for each of the eight treatments were averaged together.

TABLE 1—Oil distilled at the beginning and end of the season in 1947 and 1948

Time of season	Specific optical rotation		Percent Esters		Percent Menthol		Percent Menthone	
	1947	1948	1947	1948	1947	1948	1947	1948
Beginning...	−23.6	−23.1	5.7	4.9	50.7	48.2	31.2	31.8
End.....	−26.0	−29.5	7.3	9.3	54.5	67.2	28.0	12.4

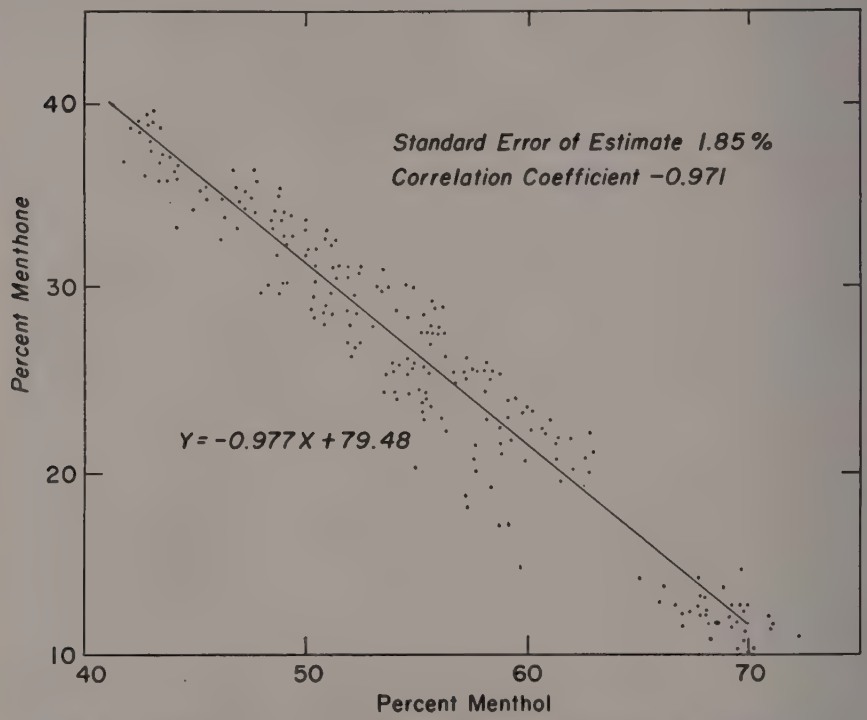

Fig. 1. Relation of menthone and menthol percentages in peppermint oil, 1947-1948.

Table 2 indicates that in 1947 there was a decrease in specific gravity, specific optical rotation, refractive index, percentage of esters, total menthol and an increase in the percentages of menthone three

TABLE 2—Effect of climatic conditions on physicochemical properties of peppermint oil

Determination	Replication		
	I(*a*)	II	III
Specific gravity	0.9024	0.9034	0.9036
Optical rotation	−21.7	−24.2	−24.6
Refractive index	1.4606	1.4610	1.4605
Percent esters	4.70	7.54	8.86
Percent total menthol	50.09	56.67	55.22
Percent menthone	31.08	25.52	27.79

(*a*) Plots from which this oil was produced were cut three days after the other plots because an exceedingly heavy rain stopped harvesting operations.

days after a very heavy rain. The rain was followed by an abundance of sunshine with relatively high temperature. This indicates a decided change in the physicochemical properties which might be interpreted to disprove the theory of the formation of menthol from menthone as the plant matures. However, these changes can be explained as follows: Previous to this rain, the plants had ceased growing and producing oil. With a sudden abundance of moisture and favorable growing conditions, growth was rapidly resumed with the formation of more oil. This oil of recent formation would naturally have different physicochemical properties from that already present and its presence would then alter the proportion of total constituents, which in turn would alter physical properties. This theory may be supported by the fact that the plots harvested after the rain had up to 10 pounds per acre more oil than those distilled prior to the rain.

TABLE 3—Pounds per acre and carrier of minor elements

Element	Carrier	Pounds of carrier per acre
Zinc	Zinc sulfate	50
Copper	Cupric sulfate	50
Iodine 1	Potassium iodide	3
Iodine 2	Potassium iodide	6
Silicon	Sodium metasilicate	100
Chromium	Potassium dichromate	50

The relation between the percentage of total menthol and optical rotation is presented in Fig. 2. A correlation coefficient of 0.077 shows that a fair relationship was obtained with 239 pairs of measurements (Fig. 2).

SUMMARY

A two-year study of peppermint oil obtained from four Michigan localities was conducted. Specific gravity, optical rotation, refractive index, contents of free esters, total menthol, and menthone were investigated.

Specific optical rotation and percentages of esters and total menthol increased, while the percentage of menthone decreased with further maturity of the plant.

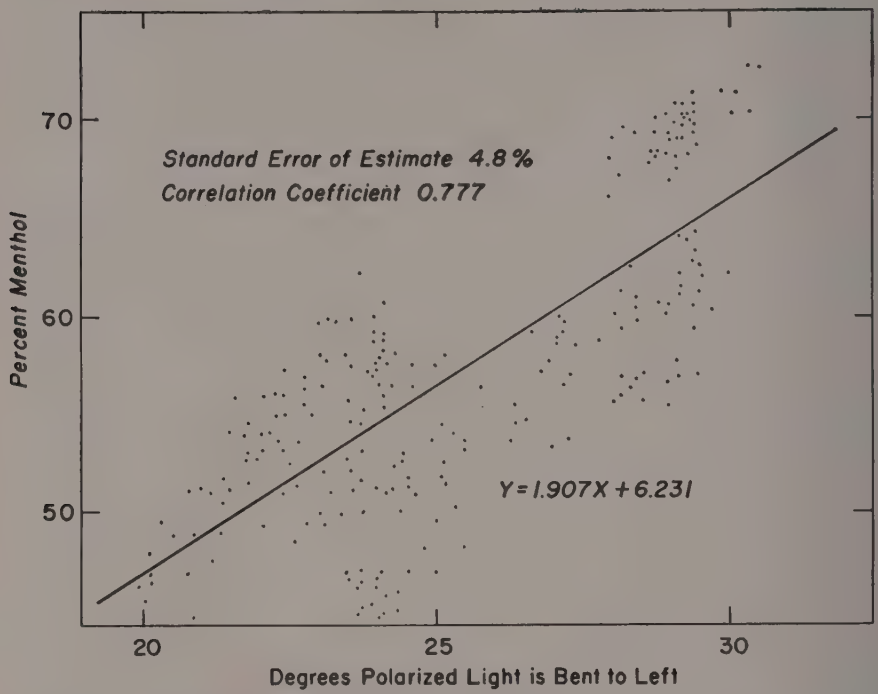

Fig. 2. Relation of specific optical rotation of peppermint oil to percent menthol in the oil, 1947-1948.

The correlation coefficient between total menthol and menthone percentages was −0.971.

The correlation coefficient between total menthol and specific optical rotation was 0.777.

Minor elements (zinc, copper, iodine, silicon, and chromium) applied to the soil did not affect yield or physicochemical properties of oil.

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PERIOD HARVESTING FOR FORAGES IN MICHIGAN

By FRED C. ELLIOTT
FARM CROPS DEPARTMENT

AMONG THE CROPS GROWN in Michigan, there is none more sensitive to deterioration in quality from rainy weather during harvest than the forages. Since they are generally harvested at an immature stage some exposure to the weather is unavoidable in field drying. Even under the most favorable field drying conditions exposure over a day or two may be required. The sight of hay bales rotting in the fields is an all too familiar reminder that prolonged rainy periods occur in the state during hay harvest and occasionally with rather serious losses resulting. Estimates of average hay losses are difficult to obtain and deterioration in quality from weather damage cannot be measured directly; however, losses ranging from 30 to 50 percent are often encountered. In the past these losses were written off as inevitable risks.

New patterns in farm operations are now emerging. Farm units are getting larger, investments in land, labor, livestock, machinery, and fertilizer are increasing and in all operational phases efficiency is stressed. This includes the production, handling and preservation of greater quantities of higher quality forages per unit than ever before. To assist in these operations new forage harvesting machines and systems are appearing in which more tractor horsepower and electricity are performing the menial tasks faster and more efficiently than previously.

With increasing investment in the operations, there is a need for stable, high level forage production embodying the best quality features attainable. Although exact measures of quality are elusive, the first step towards the attainment of high quality forage is the avoidance of deterioration which follows prolonged exposure to rainy weather.

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The interaction, then, of weather and forage harvesting is becoming more critical and every possible means of minimizing the weather hazard is worthy of careful scrutiny. Some operators have been growing a series of forage crops for harvest at different periods over the growing season in order to spread the risks of prolonged unfavorable weather. The question is often asked whether or not there are calendar periods during the growing season when rain is less likely to occur than at others. If so, the production of forage crops suited for harvest within these periods when five-day local weather forecasts are favorable should contribute greatly to the harvest of better quality forage. Such an approach would also facilitate spreading costs of labor and forage harvesting machinery over more of the growing season.

Period harvesting for forages has interesting research facets from the standpoint of weather, crops and soil management, agricultural economics, and forage improvement. Emphasis in this discussion is directed to the latter for there are many new and improved forage combinations available or in developmental stages with important contributions to make if—and perhaps only if—a more congenial relationship might be established between weather and harvesting.

Long-term weather summaries for East Lansing, South Haven, and Monroe, Michigan compiled by Baten and Eichmeier[1] reveal a number of interesting features in this connection. A composite of the average weekly precipitation in inches (see Fig. 1) indicates four periods during the growing season when rainfall was lower than at other times. The first period around May 1 and the second period during the early part of June coincided very closely for all three stations. The third period of low rainfall occurred simultaneously in the latter half of July at all three stations although there was a difference of .2 inch in precipitation. The fourth period occurred in the latter half of August at all three stations with the low point at Monroe occurring slightly later than at South Haven or East Lansing.

The evidence for more favorable periods on the average from these data is neither conclusive nor appropriate for predictive purposes, however, since the weather summarized in Fig. 1 occurred prior to 1950. If weather patterns are cyclic and changing as has been claimed for this continent, a recent summary of local weather would perhaps be more revealing for our purposes.

[1]Baten, W. D. and A. H. Eichmeier (1951, 1955 and 1958). A summary of weather conditions at East Lansing, Mich. prior to 1950; a summary of weather conditions at South Haven from 1926 to 1950; and a comparison of weather conditions at Monroe, East Lansing and South Haven, Mich., 1931-1952; Mich. State Univ. Agr. Expt. Sta., East Lansing, Mich.

The average five-day precipitation received during the growing seasons at the Experiment Station in East Lansing over the period 1949-59 inclusive may be seen in Fig. 2.[2] At first glance the favorable periods indicated from Fig. 1 are not so obvious, although closer scrutiny of this recent weather reveals patterns similar to the earlier summary. However, a summary of only 11 seasons at one location may not contain the extremes found in those of longer periods. The first part of May still appeared to be favorable for forage harvesting. Although not so well defined as the second period in Fig. 1, the first half of June in the recent summary contained two low five-day periods, the first of which actually contained six days since May has 31 days.

The six-day periods occurring at the end of July and August (31-day months) reflected the proportional increases in precipitation expected over the five-day periods. The low period in July occurred in the second five-day period as contrasted to a later period in the earlier summary. The fourth period of low precipitation also occurred after the middle of August as in the earlier summary. During September and

[2]Precipitation data made available through the cooperation of Agricultural Research Service, S.W.C., and the Michigan Agricultural Experiment Station.

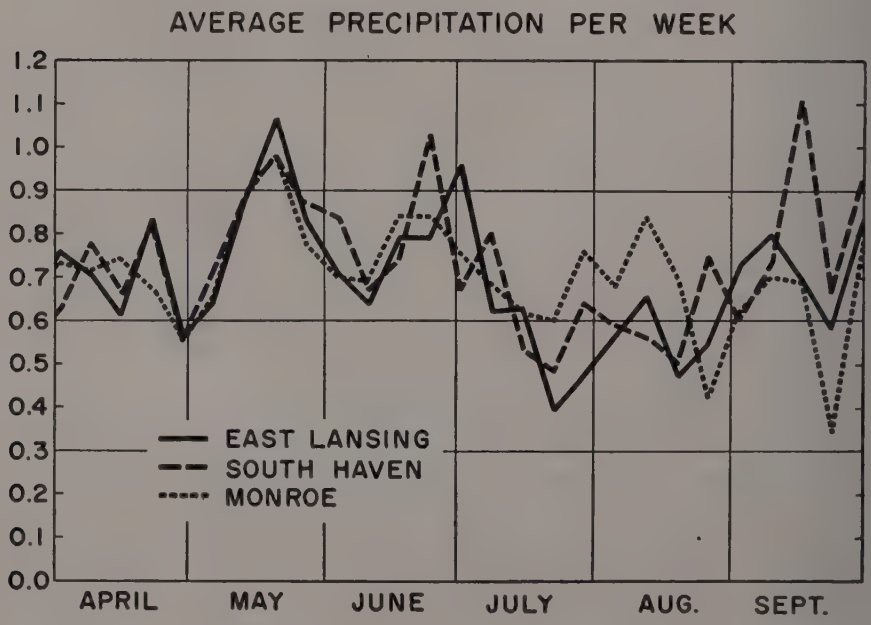

Fig. 1. Composite of average weekly precipitation in inches (redrawn from Baten and Eichmeier, 1951, 1955 and 1958).

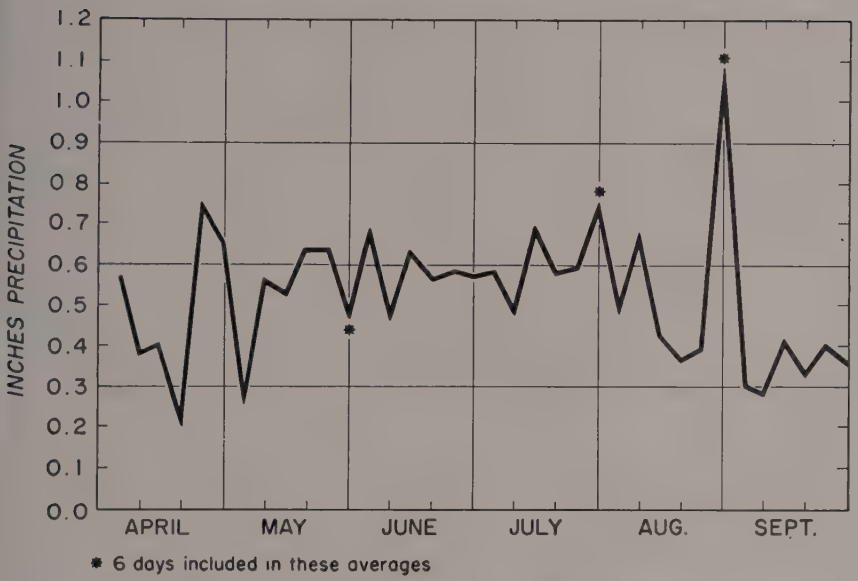

Fig. 2. Average 5-day precipitation over the period 1949-1959 inclusive at the Experiment Station in East Lansing, Michigan.

prior to killing frosts, favorable weather for corn silage harvesting should also be available based on a projection of the summary for the past 11 seasons.

Evaluation of weather based on average precipitation over five-day periods may not be too revealing unless accompanied by measures of variation such as ranges and standard deviations in day to day events since harvesting operations must proceed on this basis. For example, how many days were there in the suggested harvest periods (periods of low average precipitation) without even traces of precipitation? How many of these rain-free days were consecutive? How often did heavy rains precede these consecutive rain-free days in the various periods?

In only one period out of 44 over the 11 seasons was there less than 8 days without traces of precipitation. In the May 1-15 period of 1956 there were only four days without precipitation, three of which were consecutive. However, during April of that season only .71 inch total precipitation was received up to the 25th day. For this reason forage harvests in the May 1-15 period would have been negligible.

The mean number of days without traces of precipitation in the first two periods were essentially alike and a similar situation prevailed for the second two periods (see Table 1).

TABLE 1—Total number of days in periods without traces of precipitation (Experiment Station, East Lansing, Mich. 1949-59 inclusive)

	1st period May 1-15	2nd period June 1-15	3rd period July 15-31	4th period Aug. 15-31
Mean.....	10.2±2.8	10.0±1.3	12.4±2.1	12.1±1.9
Range.....	4-14	8-12	9-16	10-16

The number of consecutive days without traces of precipitation during periods is critical for successful harvesting operations on significant acreages. The means, standard deviations, and ranges for consecutive days without traces of precipitation are shown in Table 2. Roughly 6 consecutive days without precipitation occurred in each period over the 11 seasons although the ranges include periods with extremes of only three days and as long as 15 days. In no more than one period in each of six seasons out of the eleven, was an inch or more total precipitation received within two days prior to a five-day consecutive rain-free period.

TABLE 2—Greatest number of consecutive days in periods without traces of precipitation

	1st period May 1-15	2nd period June 1-15	3rd period July 15-31	4th period Aug. 15-31
Mean.....	6.3±2.3	5.9±1.8	5.8±2.5	7.5±3.7
Range.....	3-11	4-9	3-10	4-15

In suggesting the possibility of period harvesting, it has been assumed that projections of the average situation at East Lansing over the past 11 seasons might be used for future trial harvests over at least southern Michigan. Detailed weather studies which are beyond the scope of the present discussion may reveal the impracticality of these generalizations. Until then, however, the flexibility offered by growing a series of crops to be harvested at different periods in the growing season when five-day weather forecasts are favorable. might be an attractive objective to operators harassed by rising costs and increased investment.

A number of Michigan's common forages lend themselves well to harvesting in the suggested periods and hundreds of less common

forage introductions are under observation. With ample late winter or early spring moisture and favorable spring growing weather a number of forages are sufficiently mature for harvesting during the May 1-15 period in southern Michigan. Winter rye varieties are among the most familiar crops with forage possibilities for early period harvests. The present varieties such as Balbo, however, need improvement for forage utilization, including disease resistance and more leaves in relation to stems.

Representatives of the foxtails *(Alopecurus arundinaceus* and *A. pratensis)* are ideal early season perennial grasses for first period harvests. One of the chief drawbacks to wider use of the true meadow or creeping type foxtails has been their seed characteristics. They possess light seed covered with hairs which make them difficult to handle. However, this is a fault of numerous grasses which may be overcome soon with processed seed. A number of other grasses under observation may be suited for harvest in the first half of May. Of the legumes presently under observation, sainfoin has made more early spring growth than others.

First cuttings of alfalfa or alfalfa-brome mixtures may be made during the first half of June in southern Michigan. Emphasis on cutting the first half of June would facilitate second cuttings in the latter half of July. Early maturing alfalfas with resistance to fungous diseases contributing to leaf-spotting and stem-blackening, viruses, and to insect attack would aid materially in the harvest of higher quality forage in this area. Among the cool season grasses in addition to smooth brome are orchard grass, various fescues, bluegrasses, wheatgrasses, and other miscellaneous grasses which may also make worthwhile contributions to harvests in this period. Where alfalfa is difficult to maintain, legumes such as sainfoin, trefoil, vetch, low alkaloid lupine, and other miscellaneous species may make definite contributions to forage harvests.

By the latter half of July, temperatures are generally higher and moisture stresses may often occur. Many cool season grasses become at least partially dormant in response to the combination of low available moisture and higher temperatures. Second cuttings of alfalfa may be supplemented as late July forage by spring-sown cereals alone or with peas, spring-sown vetches or other annual legumes depending upon the specific locality.

The fourth period in the latter half of August requires forage species with adaptation to high temperatures and frequent moisture stress.

New annual and perennial grasses might contribute much more to forage harvests in this period. On small permanent pastures warm season grasses such as locally adapted bermuda grasses might contribute significantly to production in July, August, and early September. A number of annual clovers and vetches may be harvested in some areas alone or in combinations with summer sown cereals in late August. Preliminary observation of many warm season grasses and legumes may be required to find varieties with adaptation to special environments in the state.

On many Michigan farms corn silage has and will continue to play a dominant role as feed. Silage harvests made during good weather in advance of killing fall frosts will help insure the preservation of high quality feed.

CORN GRAIN AND STALKS (HAY-EQUIVALENT) IN CORN SILAGES OBTAINED FROM RANDOM SAMPLES

By C. F. HUFFMAN, C. W. DUNCAN and S. T. DEXTER

DEPARTMENTS OF DAIRY, AGRICULTURAL CHEMISTRY AND FARM CROPS

MOST STUDIES dealing with the nutritive feeding value of corn silage for milk production prior to 1954 indicated that hay, hay-crop silage, and corn silage were about equal for milk production on the dry basis. As pointed out previously by Huffman and Duncan (1954) these results had been obtained with rations adequate in grain so that the grain in corn silage could not manifest its power. Subsequent results reported by Michigan workers showed conclusively that the corn grain in corn silage was just as valuable as ear corn stored in the bin, ground into a meal, and fed in the manger (Dunn et al., 1954).

These investigations were made possible from data obtained on yields of grain and leaves and stalks per acre when random samples were taken from the corn field 1 day prior to ensiling. The samples consisted of 10 randomly selected 1/1000 of an acre for a total of 1/100 of an acre of corn stalks with leaves and ears. The ears were removed and representative samples of ears and stalks were dried. The calculated data are shown in Table 1.

The objective of this paper is to emphasize the concept that corn silage supplies grain and hay equivalents for dairy cattle feeding and that this concept gives a basis for estimating the monetary value of corn silage.

The data in Table 1 represent 11 years of collecting random samples. All the silage crops were hybrids except No. 1 (Eureka) which represents a late-maturing corn grown for silage, not for grain. Although No. 1 came from a field next to No. 2, and both were harvested at the same time, it was very immature, as indicated by the high mois-

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TABLE 1—Corn silages results from samples collected randomly

Sample number	Silage crop	Yield	Moisture	Stalks wet	Hay equiv./A in stalks	Cobs	Number 2 corn yield	Corn silage to supply 1 lb. of 14% moisture corn	14% moisture corn grain in 1 lb. corn silage	12% moisture hay-equivalent in 1 lb. corn silage
		(T/A)	(%)	(T/A)	(T/A)	(T/A)	(bu./A)	(lb.)	(lb.)	(lb.)
1	1945—Eureka.....	16.8	79.0	15.2	2.3		6.8(*a*)	88.6	....	0.23
2	1945—Ohio M-15.....	10.3	69.1	6.7	1.9	0.4	61.7	6.0	0.17	0.18
3	1946—Kings Cross.....	5.2	65.1	3.4	1.1	0.1	24.9	7.5	0.13	0.27
4	1948—Ohio M-15.....	12.8	69.7	8.8	2.1	0.4	58.8	7.8	0.13	0.20
5	1949—Ohio M-15.....	12.3	73.0	8.9	1.8	0.3	47.3	9.3	0.11	0.18
6	1950—Pioneer 373.....	11.6	68.9	7.6	2.0	0.4	55.0	7.5	0.13	0.22
7	1951—Pioneer 373.....	10.6	71.4	6.6	1.5	0.2	42.1	9.0	0.11	0.22
8	1952—Pioneer 373.....	8.2	68.4	5.2	1.1	0.3	50.4	5.8	0.17	0.18
9	1953—Funk 85-A.....	10.7	68.6	6.4	1.4	0.3	57.8	6.2	0.16	0.20
10	1954—Michigan 85-A...	15.0	72.9	10.6	2.3	0.4	70.2	7.6	0.13	0.10
11	1955—Funk 85-A.....	12.4	71.1	8.5	2.1	0.3	59.1	7.5	0.13	0.20
12	1956—Michigan 480....	17.9	72.7	12.4	3.2	0.4	65.8	9.7	0.10	0.21
	Average.....	12.0	70.8	8.4	1.9	0.3	53.9	7.6	0.13	0.20

(*a*) Not included in average.

ture content. The few small ears were in the blister stage. The hybrid corns were in the dent stage of maturity and contained about 70 percent moisture.

The 12-percent moisture hay-equivalent in the stalks varied from 1.1 to 3.2 tons per acre (average 1.9 tons). This is a very significant figure in view of our findings that corn stalk silage is equal to good hay for milk production on the dry basis. This means that a greater use of corn silage reduces the need for growing hay crops for hay or silage.

The yield of the hybrid corns used for silage varied from 24.9 to 65.8 bushels, or an average of 53.9 bushels per acre. The amount of corn silage needed to supply 1 pound of 14-percent moisture corn averaged 7.6 pounds. It is interesting that the No. 3 corn silage yielded only 24.9 bushels per acre and the No. 10 corn silage yielded 70.2 bushels per acre, but both required about the same amount of silage to give 1 pound of 14-percent moisture corn. No. 3 silage had a low stalk as well as a low grain yield due to drought conditions.

If a dairyman wishes to determine the amount of hay-equivalent and corn grain that a cow consuming 60 pounds of average silage receives, he can make these calculations from the data presented in the two columns on the right side of Table 1 by multiplying 60 pounds of corn silage by 0.13 = 7.8 pounds of 14-percent moisture corn and 60 pounds corn silage x .20 = 12.0 pounds of 12-percent moisture hay-equivalent in the stalks (samples No. 4). This means that a cow will receive 7.8 pounds of grain and the equivalent of 12 pounds of hay per day from 60 pounds of corn silage.

Sometimes there is occasion to estimate the nutritive value of corn silage per ton. This may be done by multiplying 0.13 x 2000 pounds (1 ton) = 260 pounds (4.6 bushels) of U.S. No. 2 corn and .20 x 2000 = 400 pounds of hay-equivalent in the stalks, leaves and cobs. When corn sells for $1.00 per bushel and hay for $20.00 per ton, then corn silage is worth $4.60 (corn) + $4.00 (hay) = $8.60 per ton.

The relationships of grain and hay-equivalent may be stated in another way to emphasize (the standpoint of) crop yields and utilization rather than feeding value. Table 2 includes the data for 10 individual years, omitting silage No. 1 (Eureka variety) and silage No. 3 (almost a crop failure). If the crops had been harvested and utilized as corn grain, the 10-year average would have been 56.8 bushels per acre or 12.2 tons as silage.

Over this period, the data show that one could have expected a yield of about a ton of silage for each 4.5 to 5 bushels of dry corn grain.

TABLE 2—Yield of silage in relation to the yield of dry grain from the same field, and the loss of hay-equivalents in terms of bushels of corn harvested as dry grain

Silage number	Yields per acre as			Bushels of dry grain if harvested as silage, or hay-equivalent lost	
	Silage	Hay-equiv. in stalks	Grain	Silage	Lost hay-equivalent
	(tons)	(tons)	(bu.)	(bu./T.)	(bu./T.)
2.....	10.3	1.9	61.7	6.0	32.5
4.....	12.8	2.1	58.8	4.6	28.0
5.....	12.3	1.8	47.3	3.8	26.3
6.....	11.6	2.0	55.0	4.7	27.5
7.....	10.6	1.5	42.1	4.0	28.1
8.....	8.2	1.1	50.4	6.1	45.8
9.....	10.7	1.4	57.8	5.4	41.3
10.....	15.0	2.3	70.2	4.7	30.5
11.....	12.4	2.1	59.1	4.8	28.1
12.....	17.9	3.2	65.8	3.7	28.6
Average.....	12.2	1.9	56.8	4.8	31.7

Or, if stated in another way (last column), 1 ton of hay-equivalent in feed was left in the field for each 25-30 bushels of dry grain harvested in 7 of the 10 years. In 2 years (silage Nos. 8 and 9), the stalks were comparatively short and light, and the loss of a ton of hay-equivalent was associated with over 40 bushels of harvested dry grain. Many other data from yield trials of corn grain and silage substantiate these estimates, i.e., 4.5 to 5 bushels of grain or 1 ton of silage may be harvested; 25 to 30 bushels of harvested grain equals a loss of 1 ton of hay-equivalent. In cases or regions where grain yields are rather low, the proportion of stalks to grain may be very much higher, and the silage may resemble the Eureka silage (silage No. 1) in being almost all stalks and consequently, far less valuable as feed.

The total content of a 70-ton silo of corn silage and grass silage may be similarly compared, assuming 75 percent moisture for grass silage and 70 percent for corn silage. The 70 tons of grass silage would contain 20 tons of 12-percent moisture hay, while the 70 tons of corn silage would contain 11.6 tons of hay-equivalent and 9.5 tons of dry (14 percent moisture) grain. If the 11.6 tons of hay-equivalent in the corn

silage must be plowed under because of no silage storage space, the net economic value of excellent grass silage may be very seriously reduced.

Nevens (1954) and his associates at the University of Illinois reviewed the early work on corn silage evaluation. These investigators also worked out a system of estimating the corn grain and hay-equivalent values of corn silage with various dry matter contents as shown in Table 3.

Nevens *et al.* used 15 percent moisture corn grain and 15 percent moisture leaves and stalks compared with 14 percent moisture grain and 12-percent moisture leaves and stalks in our calculations. Our corn silages averaged 29.2 percent dry matter. According to the Illinois data such silage would contain about 4.8 bushels of ears and 349 pounds of leaves and stalks per ton of silage. These results are in good agreement with our method of calculations.

TABLE 3—Ear and leaf-stalk content in 1 ton of corn silage at various stages of development(a)

Dry matter of forage	Ears(b)	Leaves and stalks(b)	Dry matter of forage	Ears(c)	Leaves and stalks(c)
(percent)	(bu.)	(lb.)	(percent)	(bu.)	(lb.)
15	0.2	342	24	3.1	347
16	0.5	343	25	3.4	347
17	0.8	343	26	3.8	348
18	1.1	344	27	4.1	348
19	1.5	344	28	4.4	348
20	1.8	345	29	4.8	349
21	2.1	345	30	5.1	349
22	2.5	346	31	5.4	350
23	2.8	346	32	5.7	350

(a) Data taken from Illinois Bulletin 576.
(b) 15 percent moisture basis, 70 pounds of ears per bushel.
(c) 15 percent moisture basis.

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THE REGRESSIVE IMPACT OF FARM PROPERTY TAXATION ON MICHIGAN FARM FAMILIES

By CLAUDE BITNER[1]

PUBLIC FINANCE SPECIALISTS often separate taxes into three types, based on their impact, or effect, on taxpayers. They are: (1) *proportional* taxes, which take a fixed proportion of a taxpayer's income; (2) *progressive* taxes, which take more in proportion of higher than lower incomes, and (3) *regressive* taxes, which take a higher proportion of a lower income than of a higher one.

The state and local tax system in Michigan has had a regressive impact on taxpayers, as illustrated in Table 1. One of the principal factors affecting this characteristic of the system is the regressive nature of the property tax, which in 1959 produced over half of all state and local taxes. The following study illustrates the regressive effect of the property tax on a specific group of Michigan taxpayers, the farmers.

In order to provide more information on the property tax burdens

[1]Formerly assistant in the department of economics, Mich. State Univ. The assistance of Raleigh Barlowe and William Heneberry of the department of agricultural economics and farm economic Research Division of the USDA, is gratefully acknowledged.

TABLE 1—Effective rates of the Michigan Tax structure

Income bracket in dollars	Percentage tax rate
Under 2,000	19.37
2,000 to 2,999	12.05
3,000 to 3,999	9.63
4,000 to 4,999	7.95
5,000 to 6,999	7.22
7,000 to 9,999	6.00
10,000 and over	5.78

Source: Richard A. Musgrave and Darwin W. Daicoff, "Who Pays Michigan Taxes?" *Michigan Tax Study, Staff Papers*, Table 5, p. 138.

of farmers, farm account records for 1957 of 922 cooperators in the Michigan Farm Account Record Project of Michigan State University were examined. Since farmers are directed to exclude taxes on their residences in their reports, results of this study apply only to differentials in tax burdens that are introduced by the taxation of productive real and personal property.

As an initial step, the accounts were grouped according to the income received by each farmer. The concept of income used in this study was the calculated cash-basis, money income of the farmer plus property taxes paid less depreciation. Incomes computed this way do not, of course, equal the real incomes of the farmers concerned. First of all, income in kind yielded by farm labor and capital devoted to the home production of consumer goods is excluded. Secondly, no estimate was made of income yielded by the investment in residential housing, i.e., the rental value of the farm dwelling. Some capital gains also were included in this measure of income, but the concept of income used was the closest approximation that could readily be made to taxable income.

After income was computed for each farmer, a percentage distribution of income receivers, incomes, and taxes were prepared. This distribution given in Table 2 reveals several facts about the incomes and tax burdens of the reporting farmers. Note that the distribution of income was uneven, being concentrated among the receivers of the higher incomes. About 25 percent of the farmers received less than $3,000 but these earned only 6.2 percent of the income received. Furthermore, about 53 percent of all farmers earned less than $5,000,

TABLE 2—Percentage distribution of income receivers, incomes, and property taxes for a selected group of Michigan farmers, 1957

Income bracket in dollars	Percent of receivers	Percent of income received	Percent of taxes paid
Under 2,000	15.2	1.3	12.7
2,000 to 2,999	10.1	4.9	8.4
3,000 to 3,999	14.9	9.9	10.4
4,000 to 4,999	13.0	11.1	10.6
5,000 to 6,999	20.2	22.9	19.7
7,000 to 9,999	17.6	27.7	22.3
10,000 and over	9.1	22.2	15.8
Totals	100.1	100.0	99.9

Source: Michigan Farm Account Records, Mich. State Univ. 1957.

but these farmers received only 27 percent of all income received. The income receivers in the lowest bracket, however, included 32 farmers who received $58,106 of negative income and paid $11,986 in taxes.

Secondly, the tax burden was disproportionately concentrated among the farmers with low incomes. The farmers in the three lowest brackets received only 16.1 percent of the income but paid 31.5 percent of the taxes. At the other end of the scale, the farmers making more than $7,000 earned 49.9 percent of the income, but they paid only 38.1 percent of the taxes.

No satisfactory statistical procedure was available to compare the tax burdens of farmers with approximately equal incomes. The farmers reporting operated farms scattered all over the state. Although many pairs of farmers with about the same income could be found living in the same counties, they probably often lived in different townships or school districts. A casual examination of farmers living in the same counties with incomes in the same $500 income brackets indicated, however, that a very wide variation often existed between farmers with almost equal incomes.

The next step followed was to compute tax-to-income ratios for each income group. These ratios along with income per receiver and taxes per receiver for each group are shown in Table 3. It reveals that persons in dissimilar economic circumstances were treated dissimilarly but that the burden was clearly heaviest for the farmers with the lowest incomes. The property tax, as levied against these farmers in 1957,

TABLE 3—Income and tax data for a selected group of Michigan farmers, 1957

Income bracket in dollars	Number of farmers	Income received	Taxes paid	Income per farmer	Taxes per farmer	Taxes as a percent of income
Under 2,000(*a*)..	140	$ 63,231	$ 50,480	$ 452	$361	79.8
2,000 to 2,999 ..	93	234,664	33,148	2,523	356	14.1
3,000 to 3,999 ..	137	478,825	41,377	3,495	302	8.6
4,000 to 4,999 ..	120	537,953	42,128	4,483	351	7.8
5,000 to 6,999 ..	186	1,109,476	78,094	5,965	420	7.0
7,000 to 9,999 ..	162	1,341,039	88,571	8,278	547	6.6
10,000 and over..	84	1,073,064	62,679	12,775	747	5.8
Totals.....	922	$4,838,252	$396,567	$5,248	$430	8.2

(*a*) The Under 2,000 Bracket includes 32 Farmers receiving $58,106 of negative income and paying $11,986 of taxes.
Source: Michigan Farm Account Records, Mich. State Univ., 1957.

was clearly neither proportional nor progressive but was highly regressive in its impact. Farmers receiving less than $4,000 had a higher tax to income ratios than the ratio of 8.2 percent calculated for all farmers considered together.

Taxes paid per farmer in the lowest two income groups, $361 and $356 respectively, were actually higher than the taxes per receiver in the next two income groups. Taxes per farmer for all reporting farmers were $430. Persons receiving more than $5,000 had higher taxes per receiver than the persons in the lower brackets, but their taxes were not proportionately higher in relation to their incomes.

Of course, the inclusion of negative incomes in the lower income groups makes the distribution of the tax burden seem especially regressive. The distribution in Table 4, which excludes those farmers with negative incomes, however, still displays marked regressivity. It also avoids a large measure of the statistical regressivity that occurs when data for only one year are used.

TABLE 4—Income and tax data, excluding negative incomes, for a selected group of Michigan farmers, 1957

Income bracket in dollars	Number of receivers	Income received	Taxes paid	Income per receiver	Taxes per receiver	Taxes as a percent of income
Under 2,000....	108	$ 121,337	$ 38,494	$1,123	$356	31.7
2,000 to 2,999 ..	93	234,664	33,148	2,523	356	14.1
3,000 to 3,999 ..	137	478,825	41,377	3,495	302	8.6
4,000 to 4,999 ..	120	537,953	42,128	4,483	351	7.8
5,000 to 6,999 ..	186	1,109,476	78,094	5,965	420	7.0
7,000 to 9,999 ..	162	1,341,039	88,571	8,278	547	6.6
10,000 and over..	84	1,073,064	62,679	12,775	747	5.8
Totals.....	890	$4,896,358	$384,581	$5,502	$432	7.9

Source: Michigan Farm Account Records, Mich. State Univ., 1957.

It is impossible to estimate, with presently available and processed data, just how much of the regressivity discovered was due to the fact that the records for only one year were sampled. Some fairly successful farms may have low or even negative net incomes in any one year due to livestock diseases or crop failures, and the inclusion of these negative figures adds to the apparent regressive impact of the tax. If average incomes and taxes over a period of years had been used to

compute the tax-to-income ratios for each income group, the regressivity would have been less marked, but, in the author's opinion, certainly would not have disappeared completely.

Regressivity was also apparent in all regions of the state. Table 5 presents data concerning incomes and tax burdens, with the income receivers grouped according to the type of farming area in which the farms were located. The farmers residing within each area were arrayed in order of income received. Each area array was then grouped into quartiles. Then income per receiver, taxes per receiver, and the tax-to-income ratio was computed for each quartile. First of all, it was noted, with two exceptions, the data showed a regressivity in the tax-to-income ratios in each area as they range from the lowest to the highest quartile. With the exceptions of the third to fourth quartile ranges in Area 7 and the second to the third quartile range in Area 10, the tax-to-income ratio decreased as size of income increased.

The regressivity apparent in all regions was due to two factors. First, taxes per receiver did not increase as income per receiver increased in some quartile ranges in some areas. Secondly, when taxes per receiver did increase as income increased, taxes did not increase proportionately to income. In areas 2, 5, 10, and 15-16-17, property taxes per receiver were lower in the second quartile than in the first. Taxes per receiver also decreased between the second and third quartiles in Areas 4 and 7, and between the third and fourth quartiles in Area 10.

Areas with low incomes per receiver tended to have low tax-to-income ratios. The two areas with the lowest incomes per receiver also had the lowest tax-to-income ratios. Only one of the areas with less than average income per receiver, $5,248, had tax-to-income ratios higher than the tax-to-income ratio of all farmers of 8.2 percent. The reasons for the comparatively low tax burdens in the Northern Michigan areas were not revealed in the data, but they probably were due largely to two factors. First, the people in these areas probably did not enjoy as high a level of governmental services as the people in the more wealthy areas. Secondly, it is possible that these areas received a disproportionate share of state aid.

Although the statistical results of this study clearly indicate that the property tax had a regressive impact on the farmers reporting, generalizing results to Michigan farmers should be done with care. Since the sample was not a random one from all farms in Michigan, a more representative sample might yield different results. The fact that the farm

TABLE 5—Per capita income, per capita property taxes, and tax-income ratios by areas and area income-quartiles, 922 Michigan farm account record cooperators, 1957

Area and quartile	Number of receivers	Income per capita	Property Taxes per capita	Taxes income
Area 1	59	5,821	528	.091
1st quartile		612	424	.693
2nd quartile		3,928	507	.129
3rd quartile		7,604	510	.067
4th quartile		11,521	681	.059
Area 2	112	6,344	503	.078
1st quartile		2,166	486	.224
2nd quartile		5,096	432	.085
3rd quartile		7,246	515	.071
4th quartile		10,868	580	.053
Area 4	49	4,583	376	.082
1st quartile		617	351	.569
2nd quartile		3,767	352	.094
3rd quartile		5,006	323	.064
4th quartile		8,530	470	.055
Area 5	216	5,901	561	.095
1st quartile		1,533	500	.327
2nd quartile		4,522	463	.102
3rd quartile		6,629	574	.087
4th quartile		10,920	861	.069
Area 6	51	6,452	584	.091
1st quartile		1,937	442	.228
2nd quartile		4,724	450	.095
3rd quartile		7,084	603	.085
4th quartile		12,528	861	.069
Area 7	70	4,756	450	.095
1st quartile		408	363	.887
2nd quartile		3,556	421	.118
3rd quartile		5,620	337	.060
4th quartile		8,947	656	.073
Area 8	89	5,972	462	.077
1st quartile		1,167	351	.300
2nd quartile		4,295	393	.092
3rd quartile		6,943	447	.064
4th quartile		11,242	651	.058

Source: Michigan Farm Account Records, Mich. State Univ., 1957.

TABLE 5—Concluded

Area and quartile	Number of receivers	Income per capita	Property Taxes per capita	Taxes income
Areas 9, 12 and 14.....	108	4,003	237	.059
1st quartile.....		1,192	185	.155
2nd quartile.....		3,308	192	.058
3rd quartile.....		4,459	229	.051
4th quartile.....		7,053	343	.049
Area 10.....	62	4,841	366	.076
1st quartile.....		1,811	399	.221
2nd quartile.....		4,137	270	.065
3rd quartile.....		5,791	403	.070
4th quartile.....		8,024	396	.049
Areas 15, 16 and 17.....	106	3,388	177	.052
1st quartile.....		958	179	.187
2nd quartile.....		2,792	143	.051
3rd quartile.....		3,793	158	.042
4th quartile.....		5,824	224	.038
All Areas.....	922	5,248	430	.082
1st quartile.....		1,321	378	.286
2nd quartile.....		4,067	365	.090
3rd quartile.....		6,031	422	.070
4th quartile.....		9,534	555	.058

account cooperators enjoyed relatively high incomes would dictate the inclusion of more low income operators than in the sample used in this study.[2] This would probably cause measured regressivity to be even higher than was indicated here.

Several possibilities exist for alleviating the regressive impact of farm property taxation. For example, (1) assessment techniques could be improved to provide a closer correlation between assessed valuations and income producing ability in areas where income-producing ability is the best measure of market value; (2) the present statutory exemption of farm personal property could be increased; and (3) the importance of the property tax could be deemphasized by providing for the use of non-property taxes by local units of government or by increasing state aid to counties, townships, and schools.

[2]Total net income per farm after payment of property taxes, was $4,818 on the 922 farms in the sample. Total net income per farms averaged $1,909 for all farms in Michigan, according to the September, 1959 issue of the Farm Income Situation, FIS-17S, AMS, USDA).

MICHIGAN PULPWOOD PRODUCTION AND MARKETS[1]

By LEE M. JAMES and GORDON D. LEWIS[2]

PULPWOOD PRODUCTION plays an important role in Michigan's economy. Many thousands of farmers and other workers find employment in this industry. The annual woods work-load totals between 5,000 and 6,000 man-years of labor, producing in 1958 some 900,000 cords of pulpwood worth about $27 million, delivered to pulp mill markets.

Nearly half of the volume of the raw product is shipped to Wisconsin, where it provides the basis for a substantial part of Wisconsin's pulp and paper industries. The volume retained in Michigan provides the primary basis for the state's own pulp and paper industries. These Michigan industries employed 33,000 workers in 1957 and paid wages and salaries totaling $159 million. The value added by manufacture amounted to $272 million.[3]

PULPWOOD PRODUCTION, EXPORTS, AND IMPORTS

Pulpwood production in Michigan totaled 900,000 cords in 1958. Exports, virtually all to Wisconsin, amounted to 441,000 cords. Imports, chiefly from Canada, totaled 91,000 cords.

Trends in Total Volume

Little upward trend can be seen in pulpwood production statistics in Michigan from 1946 to 1958 (Fig. 1). The increase between the end years of the series was 7 percent, although the trend line would reflect a somewhat greater increase. In contrast, national pulpwood

[1]This article brings up-to-date and expands some of the data on pulpwood production and markets presented in an earlier report by the senior author (Marketing Michigan Pulpwood, Special Bulletin 411, Mich. Agr. Expt. Sta., East Lansing, 1957).

[2]Respectively, professor of forestry, Michigan State Univ., and instructor in forestry, Montana State Univ.

[3]U. S. Bur. Census (1959). Annual Survey of Manufacturers—1957, *Washington, D. C.*

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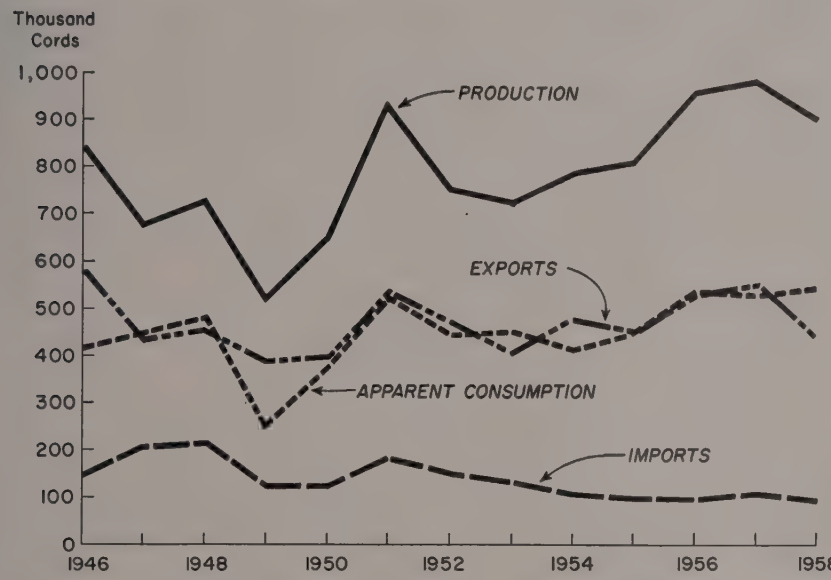

Fig. 1. Pulpwood production, exports, imports, and apparent consumption in Michigan: 1946-58. (Source: Lake States Forest Experiment Station, U. S. Forest Service, St. Paul, Minnesota.)

production jumped 96 percent from some 17 million cords in 1946 to 33 million cords in 1958.[4] In Wisconsin, the increase over the same period was 93 percent.

Annual pulpwood exports from Michigan and the apparent consumption[5] of pulpwood within the state have followed remarkably similar paths. Both series have fluctuated mainly between 400,000 and 600,000 cords annually, although the trend of apparent consumption is slightly upward in contrast to the trend of exports, which is nearly horizontal. Relative stability in exports stems from the fact that exports are mainly from the western half of the Upper Peninsula and their flow is to nearby mills in Wisconsin.

Imports, mainly from Canada and moving by water to one mill in Lower Michigan, have trended downward. Imports comprised 19 percent of domestic production in 1946; 10 percent, in 1958.

Because Wisconsin draws heavily on Michigan sources of pulpwood, any analysis of pulpwood production in Michigan must take note of production and consumption trends in Wisconsin.

[4]U. S. Forest Service (1959). The Demand and Price Situation for Forest Products, Washington, D. C.

[5]Pulpwood production plus imports minus exports.

Apparent annual consumption is much greater in Wisconsin than in Michigan, but the wide annual fluctuations and the slightly upward trend from 1946 to 1958 are similar (Fig. 2). The instability of the Wisconsin market implied in Fig. 2, however, has been transferred largely to more distant (hence, more expensive) sources of wood supply. Imports from nearby Michigan sources have held a steadier course during this period, while local wood production in Wisconsin has increased on a rising curve free of the wide fluctuations characteristic of imports from other regions.

Trends by Species

In terms of species, some important shifts in Michigan pulpwood production have taken place (Fig. 3). Historically, softwoods have been generally preferred for pulping because they are more homogeneous, easier to pulp and their longer fibers give greater sheet strength. However, mainly because of the relatively limited forest resource in softwood species, use has been shifted heavily to the abundant aspen resource.

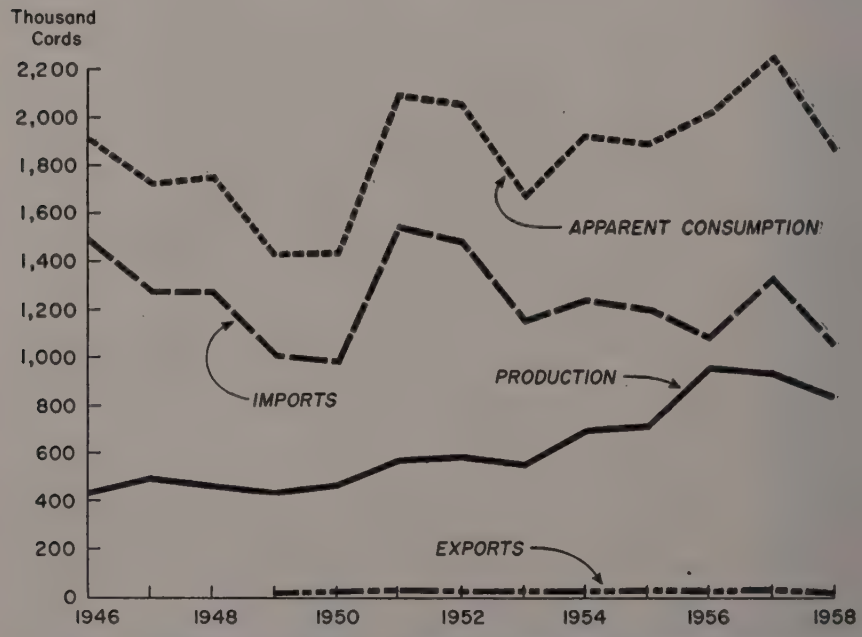

Fig. 2. Pulpwood production, exports, imports, and apparent consumption in Wisconsin: 1946-58. (Source: Lake States Forest Experiment Station, U. S. Forest Service, St. Paul, Minnesota.)

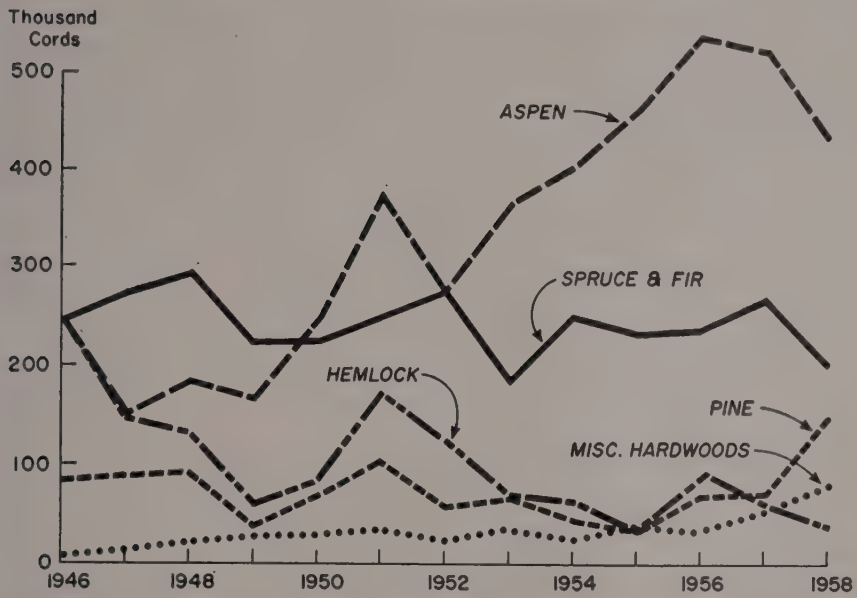

Fig. 3. Pulpwood production in Michigan by major species: 1946-58. (Source: Lake States Forest Experiment Station, U. S. Forest Service, St. Paul, Minnesota.)

Softwood species, which comprised 70 percent of Michigan's pulpwood production in 1946, accounted for 43 percent in 1958. The decline in spruce and fir production from 1946 to 1958 has been slight, but hemlock dropped drastically from 30 to 4 percent of the total. Pine production declined from 10 percent in 1946 to 5 percent in 1955, but has risen sharply to 17 percent of the total in 1958.

Aspen production jumped from 29 percent of the total in 1946 to a peak of 57 percent in 1955. Some relative decline has occurred since that date, down to 48 percent in 1958; it has been nearly compensated for by increases in the production of miscellaneous hardwoods.

Unlike Michigan, where there has been little increase in total pulpwood production, Wisconsin's output nearly doubled from 1946 to 1958. Production of any species in Wisconsin would have to increase substantially merely to hold its own in terms of percentage.

Thus, spruce and balsam fir, which have held their own in absolute volume (Fig. 4), dropped from 19 to 10 percent of the total output. Similarly, hemlock dropped from 15 to 7 percent. Only pine, among Wisconsin's softwoods, has had its output increased markedly, with the

result that its percentage has remained virtually unchanged at 18. Figure 4 shows a great increase in aspen production, but in relative terms, aspen, comprising 45 percent of the total, has barely held even. Of all species groups in Wisconsin, only miscellaneous hardwoods reflect a relative increase in output—from virtually zero to 18 percent.

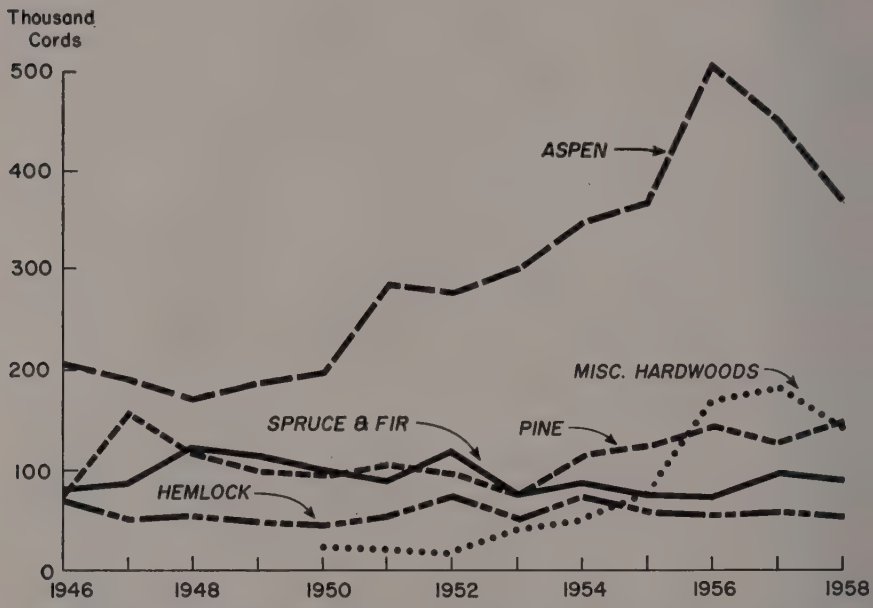

Fig. 4. Pulpwood production in Wisconsin by major species: 1946-48. (Source: Lake States Forest Experiment Station, U. S. Forest Service, St. Paul, Minnesota.)

GEOGRAPHIC SOURCES OF PULPWOOD PRODUCTION

The regional pattern of pulpwood production in Michigan is shown in some detail in Fig. 5. Data were compiled by groups of counties rather than individual counties as was done in 1954.[6]

All counties of the Upper Peninsula are substantial sources of pulpwood, with the heaviest production occurring in the western half of the peninsula. This pattern is related to pulp mill locations.

In the Lower Peninsula, which accounts for 38 percent of the total, most production is centered in the northern counties where pulpwood species in demand occur most frequently. Unlike the situation in 1954, when production was concentrated in the western portion of the

[6]James, Op. cit.

Fig. 5. Production of pulpwood of all species in Michigan by reporting areas, 1958. (Source: Division of Forestry, Michigan Department of Conservation, Lansing, Michigan; Lake States Forest Experiment Station, U. S. Forest Service, St. Paul, Minnesota; and mill questionnaires.)

Each dot represents 1,000 standard cords.

northern counties, the 1958 map shows production to be spread throughout the northern counties. In fact, the locus of heaviest concentration is now on the eastern side of the peninsula. This change is tied to the development of new pulp mill markets.

Geographic sources of various pulpwood species are indicated broadly in Table 1. Aspen, comprising 48 percent of all pulpwood production, is a large component of the total output in each of the

four broad regions of the state. Since 1954, aspen output has increased in all regions except the eastern half of the Upper Peninsula, where a substantial decline has occurred.

Production of spruce and fir, the most valuable pulpwood species, remains centered in the Upper Peninsula where these species are largely located. Pine production is still concentrated in the northern half of the Lower Peninsula, but it has increased significantly since 1954 in all of the northern regions. Hemlock production, destined almost entirely for Wisconsin mills, continues to decline and is confined largely to the western half of the Upper Peninsula. The output of miscellaneous hardwoods tripled from 1954 to 1958, but virtually all of the expansion has occurred in the western half of the Upper Peninsula; a small decline in output took place in the Lower Peninsula.

TABLE 1—Pulpwood production in Michigan, by region and species: 1958

Species	Upper Peninsula		Lower Peninsula		All Michigan
	West half(*a*)	East half(*b*)	North half(*c*)	South half(*c*)	
	Thousand cords				
Aspen and white birch..	173	46	190	26	435
Spruce and balsam fir...	115	78	9	..	202
Pine.....	15	33	100	1	149
Hemlock.....	32	3	...	...	35
Misc. hardwoods.....	58	4	10	7	79
Total.....	393	164	309	34	900

Source: Division of Forestry, Michigan Department of Conservation, Lansing, Michigan; Lake State Forest Experiment Station, U. S. Forest Service, St. Paul, Minnesota; and mill questionnaires.
(*a*) Eastward to and including Marquette and Dickinson Counties.
(*b*) Westward to and including Alger, Delta, and Menominee Counties.
(*c*) North and South halves of Lower Peninsula divided roughly by line drawn from Bay City to Muskegon.

PULPWOOD MARKETS

The 1958 markets for Michigan pulpwood included all of the 13 active pulp mills in Michigan and 23 of the 29 mills located in Wisconsin. The 36 mills were owned by 25 pulp and paper companies.

Location of Mills

Locations of the mills which make up the current Michigan pulpwood market are shown in Fig. 6. Seven mills are located in the Lower

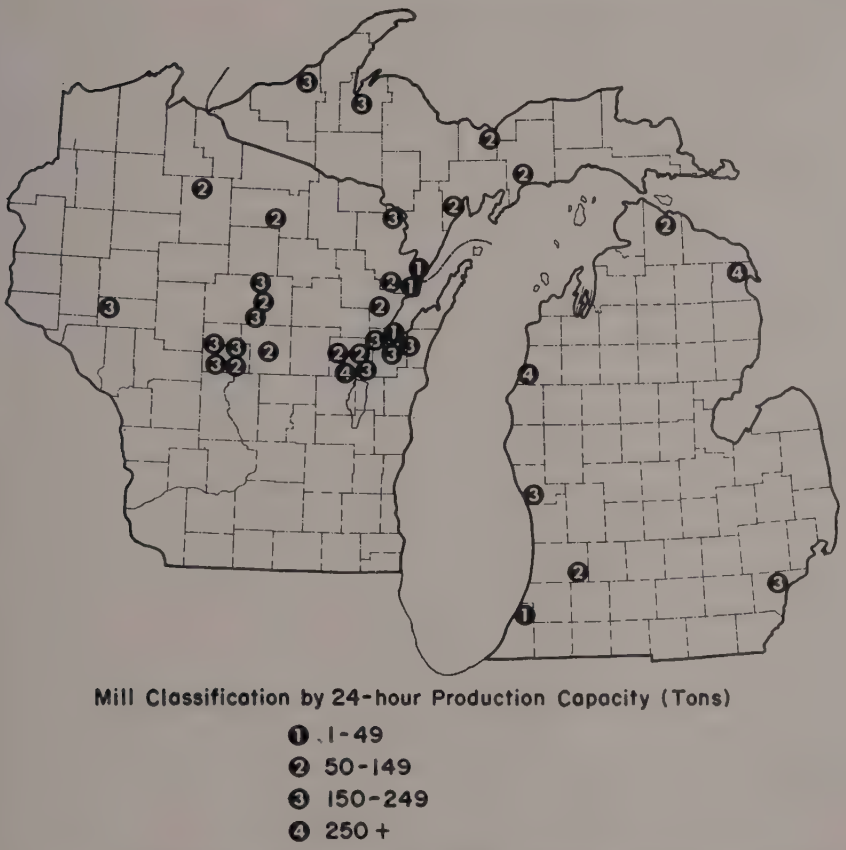

Fig. 6. Location and size of pulp mills using pulpwood produced in Michigan, 1959. (Source: U. S. Forest Service, Woodpulp Mills in the United States, Division of Forest Economics Research, Washington, D. C., 1959.)

Peninsula: four on the west side; two on the northeastern edge; one on the southeastern edge. Of the six Upper Peninsula mills, four are concentrated in the middle of the peninsula and two are on opposite sides of the base of the Keweenaw Peninsula. The Wisconsin mills are mainly in two clusters: the Green Bay area, and the mid-state area.

Four Michigan mills—two of them newly constructed and two, previously inactive—have been additions to the pulpwood market since 1954. These are the two mills on the northeastern edge of the Lower Peninsula and the two mills at the base of the Keweenaw Peninsula.

Dependence on Michigan Sources of Wood

With one conspicuous exception, the Lower Peninsula mills rely almost exclusively on sources of wood within the peninsula. Moreover, about 95 percent of all the pulpwood produced in the Lower Peninsula is destined for local markets (Table 2). The one mill which reaches outside for the main portion of its wood supply imports from eastern Canada by water.

TABLE 2—Geographic source of pulpwood consumed by pulp mills in Michigan and Wisconsin: 1958

Geographic source	Michigan lower peninsula mills	Michigan upper peninsula mills	Wisconsin mills	All mills
	Thousand cords			
Michigan:				
Upper peninsula.....	3	130	420	553
Lower peninsula.....	325	0	22	347
Wisconsin.....	0	0	811	811
Minnesota.....	0	7	267	274
Western United States	0	0	55	55
Canada.....	76	8	291	375
Total.....	404	145	1,866	2,415

Source: Lake States Forest Experiment Station, U. S. Forest Service, St. Paul, Minnesota; and mill questionnaires.

Only 5 percent of Michigan's pulpwood is produced in the southern half of the Lower Peninsula, with most of this volume going to one mill. Three mills are located within the area, and a fourth mill is on the northern edge, but all of these mills look elsewhere for their wood supply. The reason lies in the available timber resource of the southern portion of Michigan: a lack of suitable concentrations of the species in demand for pulpwood. Would-be suppliers in this area have had few opportunities to market their wood.

Market outlets in the northern half of the Lower Peninsula are more numerous, since all seven Lower Peninsula mills reach into this area for wood supplies and most of the mills rely almost exclusively on these counties. However, this cannot be construed to mean many market outlets for any given supply area. Pulpwood production is greatly limited by transportation cost. Production is usually heaviest close to the mills and tapers off as distance from mills increases. This

pattern, with some exceptions, is reflected in Fig. 5. At least two-thirds of the northern half of the Lower Peninsula falls within the procurement territories of single mills or, at best, two mills. No more than a third of the area has, practically speaking, access to three or more mill outlets.

The six Upper Peninsula mills are largely oriented to local wood supplies. About 90 percent of their wood receipts in 1958 was obtained within the peninsula. Some 10 percent was imported from Minnesota and Canada (down from 23 percent in 1954), but virtually no wood was brought in from Wisconsin or the Lower Peninsula. The two mills at the base of the Keweenaw Peninsula draw wood mainly from the western end of the Upper Peninsula. The other four mills, grouped in the middle of the peninsula, draw largely from the middle and eastern areas of the peninsula.

Wisconsin mills are the market for three-fourths of the output of Upper Peninsula wood, although Table 2 makes it clear that geographic competition of wood supply areas for the Wisconsin market is widespread. Wisconsin mills obtained 43 percent of their wood supply in 1958 from within the state, 24 percent from Michigan, 14 percent from Minnesota, 3 percent from western United States, and 16 percent from Canada (western Canada as well as Ontario). All of the 23 Wisconsin mills reaching into the Upper Peninsula for wood supplies tap the western half; seven of them reach into the eastern half also, but on a diminishing scale as transportation costs come into play. Thus, except for the eastern end of the Upper Peninsula, market outlets for pulpwood are relatively numerous.

Markets by Species

The competitive aspects of the marketing situation in terms of species is partly shown in Table 3. Of the 328,000 cords of Michigan-produced pulpwood consumed by Lower Peninsula mills in 1958, about 60 percent was aspen. This is the most widely used species, but it cannot be assumed that there is sharp competition for aspen. The aspen resource is fairly plentiful. Moreover, more than 60 percent of the 1958 total output of aspen in the peninsula went to two mills whose procurement territories are largely separate. Pine use was limited to three mills, and one of these consumed more than half of the total output. Of the three mills using mixed hardwoods, one took some 60 percent of the output.

These observations do not mean that Lower Michigan mills have an easy time getting wood supplies, since other factors such as local timber supply and woods labor can be procurement problems. What is clear is that the mills do not, for the present at least, have to vie sharply with each other or mills elsewhere for pulpwood from the Lower Peninsula.

The six Upper Peninsula mills used only 130,000 cords of Michigan wood in 1958, but the situation must be viewed against the background of 442,000 cords of wood exported from Michigan to Wisconsin pulp mills. With 23 Wisconsin mills reaching into Michigan for 213,000 cords of aspen, 137,000 cords of spruce and fir, and 42,000 cords of pine, it is clear that competition is sharpened by the considerable overlapping of supply areas.

TABLE 3—Michigan-produced pulpwood consumed by Michigan and Wisconsin pulp mills (by species): 1958

Species	Michigan lower peninsula mills	Michigan upper peninsula mills	Wisconsin mills	All mills
	Thousand cords			
Aspen and white birch	196	26	213	435
Spruce and balsam fir	9	55	137	201
Pine	100	7	42	149
Hemlock	(*a*)	0	35	35
Misc. hardwoods	23	42	14	79
Total	328	130	442(*b*)	900(*b*)

Source: Lake States Forest Experiment Station, U. S. Forest Service, St. Paul, Minnesota; Division of Forestry, Michigan Department of Conservation, Lansing, Michigan; and mill questionnaires.
(*a*) Negligible.
(*b*) Includes about 1,000 cords of tamarack.

In general, Lower Michigan pulpwood producers have few choices in pulp mill market outlets (but more than in 1954); Upper Michigan producers have few outlets at the eastern end of the peninsula, but many possible outlets at the western end.

RESOURCE BASIS FOR PULPWOOD PRODUCTION

The pulpwood market situation in Michigan has been discussed without reference to the adequacy of the forest resource. Production data have been reviewed by regions and related to the pulp mill

markets for Michigan wood within the state and in neighboring Wisconsin. It has been shown, in relation to species use and locations of procurement territories, that market outlets are generally limited with the exception of the western portion of the Upper Peninsula.

However, market outlets are generally more limited when viewed within the framework of forest inventory data. The fact that a producing area falls within the procurement territory of a pulp mill or within the overlapping procurement territories of a number of mills does not insure a pulpwood market. In any given period, pulp mills consume a fixed amount of pulpwood. If more timber is available than the mills consume, the surplus timber is left without a market.

Much of Michigan's pulpwood resource is, in fact, without a market. Overall production has trended upward, but the increase has not been keeping pace with the increase in the available forest inventory.

Allowable cut is a concept widely used in the Lake States to indicate the volume that may be removed during a given period while building up or maintaining sufficient growing stock to meet specified growth goals. It is a tenuous concept in that it is based only partly on growth estimates; it takes into account a number of factors such as forest types, species composition, stand size classes, and the economic feasibility of logging operations. In the heavily depleted forest of Michigan, allowable cut is a conservative concept. It is generally set well below actual growth to permit the building up of forest inventories to levels considered desirable by foresters. For example, a recent Forest Service report shows the total allowable cut in pulpwood-size timber to be 56 percent of growth in the Upper Peninsula and 46 percent of growth in the northern half of the Lower Peninsula.[7]

Pfeifer recently compiled data on the allowable pulpwood cut estimates and the actual 1958 pulpwood cut in Michigan.[8] These data have been summarized in Table 4.

In aspen, the annual excess of allowable cut over actual cut is 706,000 cords. If the present cut was doubled, a large excess of allowable cut would remain. In all regions, particularly in the eastern Upper Peninsula, the annual cut could be greatly expanded provided expanded market outlets were available. Among miscellaneous hardwoods, the situation is even more distorted: an excess of 406,000 cords in comparison with a current cut of 79,000 cords. It is this situation

[7]U. S. Forest Service (1959). Feasibility of Using Lake States Hardwoods for Newsprint and Other Pulp and Paper Products, Washington, D. C. 84 pp.

[8]Pfeifer, Ray E. (1959). Pulpwood Procurement and Allowable Cut in Michigan, Division of Forestry, Michigan Department of Conservation, Lansing, Michigan.

TABLE 4—Excess of annual allowable pulpwood cut over actual pulpwood cut in Michigan, by region and species, 1958

Species	Upper peninsula		Lower peninsula		All Michigan
	West half(*a*)	East half(*b*)	North half(*c*)	South half(*c*)	
	Thousand cords				
Aspen and white birch..	115	242	306	43	706
Spruce and balsam fir...	6	63	27	...	96
Pine.....	−6	16	−11	−1	−2
Hemlock(*d*).....	33	40	8	...	81
Misc. hardwoods.....	48	88	195	75	406
Total.....	196	449	525	117	1287

Source: Pfeifer, Ray E. (1959). Pulpwood Procurement and Allowable Cut in Michigan, Division of Forestry, Michigan Department of Conservation, Lansing, Michigan.
(*a*) Eastward to and including Marquette and Dickinson Counties.
(*b*) Westward to and including Alger, Delta, and Menominee Counties.
(*c*) North and South halves of Lower Peninsula divided roughly by line drawn from Bay City to Muskegon.
(*d*) Small amounts of tamarack also included.

which is focusing attention on hardwoods as a reservoir of potential pulping stock.[9]

Even in softwoods, commanding the highest pulpwood prices and generally assumed to be in short supply, there is some excess of allowable cut over actual cut. The excess is very small in two of the three softwood regions of Michigan, but in the eastern Upper Peninsula the excess is twice as large as the present actual cut.

Pulpwood markets are absorbing all the timber that can be safely taken of a few species in some regions, but in general, far more pulpwood timber is available for cutting in Michigan than is being consumed by pulp mills.

[9]Federal Reserve Bank of Minneapolis (1959). Lake States Pulping Looks to Hardwoods, Monthly Review 14 (11): 7-11.

AN EVALUATION OF SYSTEMIC INSECTICIDES FOR CONTROL OF INSECTS ON SNAP AND FIELD BEANS

By GORDON GUYER, ARTHUR WELLS, AXEL L. ANDERSEN[1] *and DONALD J. DeZEEUW*

DEPARTMENTS OF ENTOMOLOGY AND BOTANY AND PLANT PATHOLOGY

INSECTS AND INSECT TRANSMITTED DISEASES are serious problems in production of beans in Michigan. There has been an increased interest and emphasis for insect control on this crop. Because of recent developments using systemic insecticides for insect control (Andres *et al* 1959, Bishop and Burkhardt 1959, Hopkins *et al* 1959, Guyer *et al* 1958, and Way 1959), it was thought this technique might be applied to insect control on beans. Way and Needham (1957) reported that beans could be protected systemically from aphid infestations by using demeton applied directly to seeds or into the soil. This investigation evaluated systemic insecticides for controlling chewing and sucking pests on snap and field beans.

METHODS

Snap Beans, 1957

Four formulations of phorate (Thimet) and Di-syston (Bayer 19639) were evaluated at the Sodus Experimental Farm, Berrien County, Michigan, using a four-replicated randomized block design. Each insecticide was applied either as a seed treatment or a granular formulation in the furrow with the seed using a V-belt seeder. Each treatment consisted of 50 seeds planted in a 10-foot row with a 30-inch spacing. The seed was treated on June 4 and planted the following day. The Kinghorn Special variety was used in all treatments. Stand counts, Mexican bean beetle (*Epilachna varivestis* Muls.) damage, and bean mosaic severity ratings were made on July 25. The beans were harvested on July 25, July 31, and August 30 yield comparisons.

[1]Senior Pathologist, Crops Research Division, Agricultural Research Service, United States Department of Agriculture.

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Snap Beans, 1958

In 1958, experiments were conducted on the University Farm at East Lansing and the Sodus farm in Berrien County. Kinghorn Special seed was treated June 2 and the plant at Sodus June 5 and June 16 at East Lansing. Stand counts were made at Sodus on June 26 and August 15 and July 17 at East Lansing. Mosaic severity ratings from the Sodus plots were made on August 8 and yields were obtained on August 3, 15, and 23, 1958.

Samples of beans from field and plot plantings of snap beans treated with phorate were sampled for residue analysis.

Field Beans, 1959

Effects of systemic insecticides on insects and diseases of field beans were studied in 1959 in plots located in Saginaw, Tuscola and Montcalm Counties. The Tuscola County experiment was planted with Sanilac seed. Each of six treatments consisted of a one-row plot, 600 feet long and replicated three times, using a 28-inch row spacing. Two hundred pounds of 3-12-12 fertilizer was applied in the row before planting. The phorate-fertilizer treatment was placed in the fertilizer box and sidedressed at the time of seeding at the rate of 200 pounds of 5-20-20 per acre. The remaining treatments did not receive additional fertilizer. The granular formulations were applied in the row with the seed at the time of seeding with a Gandy Inrow Applicator attached to the seeder. Stands were determined by counting the plants in ten 4-foot areas, selected at random along each row. Yield data were obtained by threshing and weighing the dry beans from plants taken from four 20-foot samples selected at random. Plantings were made, stand counts taken, and beans harvested on June 3, July 2, and September 9, 1959, respectively.

The Michelite, cranberry, and dark red kidney varieties were used in Saginaw County experiments. Insecticides and methods of application were the same as those used in the Tuscola County plots. No preplanting application of fertilizer was made, but plots were sidedressed as above at planting time. Each treatment in the Michelite plots consisted of two 400-foot rows whereas, in the dark red kidney beans, only one 400-foot row was used for each treatment. The cranberry beans were planted in two replications using single 100-foot rows. The plots were randomly sampled for stand counts on July 2 and yield data on September 9.

Effects of phorate, when applied as a granular formulation in fertilizer to 1 acre plots of field beans also were studied in 1959. These plots were located in commercial fields of cranberry and yellow-eye beans in Montcalm County. Ten pounds of 10 percent granular phorate was mixed with fertilizer and applied to 1 acre with a bean drill at the time of planting. Plots of untreated beans, equal in size and located beside the treated areas, were designated as controls. Weekly observations were made on all experiments in 1959 to determine the composition and magnitude of insect populations and disease infections. The plots were randomly sampled for stand and yield data.

DISCUSSION OF RESULTS

Results from the 1957 investigations on snap beans are presented in Table 1. These data show a serious reduction in plant emergence evident in the plots planted with treated seed, while a moderate reduction was evident in those receiving phorate granules as furrow treatment. There was a significant reduction in bean mosaic symptoms in the plots receiving granulated formulations. It was impossible to ascertain whether reduction of mosaic symptoms was due to the general increase in plant vigor or actual reduction of the condition due to destruction of vectors. There was a significant reduction in feeding injury by the Mexican bean beetle on plants grown from phorate and

TABLE 1—Effects of insecticide treatments on plant stands, mosaic, insect damage and yields of Kinghorn Special snap beans, Sodus, Michigan, 1957

Material	Amount of toxicant	Percent stand 50 days	Damage rating(*a*)		Yield (cwt./-acre)
			Bean mosaic	Bean beetle	
Phorate 44D.....	1 lb./100 lb. seed .	40.0	3.0	1.25*	64.47*
Phorate 2% Gran....	1 lb./acre.....	50.0	1.75*	1.50	135.04*
Di-syston 50% carbon.....	1 lb./100 lb. seed .	42.0	2.75	1.25*	88.43
Di-syston 2.5% Gran.....	1 lb./acre.....	72.5	2.25*	1.75	145.06*
Control (seed only)..	.....	71.0	4.00	2.50	96.27
Maximum 5% range(*b*).....	.....	36.0	1.48	1.12	19.86

(*a*) Damage rating: 1 = No damage; 2 = Light (less than 10%); 3 = Medium (10-50%); 4 = Severe (50-100%).
(*b*) Maxmium range at 95% confidence level from a multiple range test (Duncan 1955).
* Indicates significance from the control at the 5 percent level.

Di-syston treated seed and a general reduction with granulated treatments. There was a significant increase in yield from plots receiving the granulated formulations of both phorate and Di-syston. A significant reduction in yield was evident in the phorate seed treatment plot, which appeared to be associated with the poor stand resulting from the phytotoxicity of the seed treatment.

Studies in 1958 at Sodus and East Lansing were primarily concerned with effects of the various systemic materials on plant stands. Poor emergence was evident in the East Lansing plots as a result of deep-planting and heavy soil (Table 2). There was a consistent decrease in plant stands as a result of the phorate, Di-syston, and phosphamidon seed treatments. Both American Cyanamid 12880 and 18706 significantly increased stand at East Lansing. No explanation was

TABLE 2—Effects of insecticide treatments on stands, mosaic damage, and yields of Kinghorn Special snap beans, East Lansing and Sodus, Michigan, 1958

Material	Amount of toxicant	East Lansing percent stand 31 days	Sodus			
			Percent stand		Mosaic rating(*a*)	Yield (cwt./acre)
			21 days	71 days		
Phorate 44D.....	1 lb./100 lb. seed .	3.0*	58.0	54.0	3.25	52.27
Phorate 44D.....	2 lb./100 lb. seed .	2.4*	37.0*	32.5*	2.50	43.56
Phorate 44D + Arasan 75	2 lb./100 lb. seed +1 lb. of A75/100 lb. seed	17.0	70.5	41.5*	2.50	70.22
Phorate 2% gran.....	2 lb./acre.....	30.4	39.5*	35.5*	2.63	54.89
Di-syston 50% carbon	1 lb./100 lb. seed .	1.0*	26.5*	24.0*	2.38	33.63*
Di-syston 5% gran...	2 lb./acre.....	1.0*	41.5*	35.0*	2.25*	53.14
Phosphamidon 4 E.C.	1 lb./100 lb. seed .	2.4*	23.5*	18.5*	3.75	24.05*
Phosphamidon 5% gran.....	2 lb./acre.....	10.0	75.5	65.0	2.63	72.31
Amer. Cyan. 12880(*b*) 2% gran.	2 lb./acre.....	46.0*	50.0*	41.0*	2.38	71.96
Amer. Cyan. 18706(*c*) 2% gran..	2 lb./acre.....	69.4*	74.5	64.0	1.75*	78.93
Shell SD3562(*d*).....	1 pt./100 lb. seed .	18.0	78.5	67.0	3.38	40.95
Bayer 25141 (Ent. 24945(*e*) 2.5% gran.....	2 lb./acre.....	6.0	.....	.....	.....	.....
Bayer 29493 (Ent. 25540)(*f*) 2.5% gran.....	2 lb./acre.....	4.0	.....	.....	....	.....
Control.....	.....	18.4	76.5	65.5	3.50	67.08
Maximum 5% Range(*g*).....	.....	14.6	23.2	23.7	1.15	30.21

(*a*) Mosaic infection rating: 1 = No damage; 2 = Light (less than 10%); 3 = Medium (10-50%); 4 = Severe (50-100%).
(*b*) *0,0*—dimethyl *S* (*N*-methylcarbamoylmethyl) phosphorodithioate
(*c*) *0,0*—dimethyl *S* (*N*-ethylcarbamoylmethyl) phosphorodithioate.
(*d*) 3-(Dimethoxyphosphinyloxy)-*N,N*-dimethylcrotonamide.
(*e*) *0,0*-Diethyl, *O*-*p*-(methylsulphoxy) phenyl-phosphorothioate.
(*f*) *0,0*-Dimethyl *0*-[4- (methylthio)-*m*-tolyl] phosphorothioate.
(*g*) Maximum range at 95% confidence level from a multiple range test (Duncan 1955).
* Indicates significance from the control at the 5 percent level.

evident for this increase in emergence and development. At Sodus there was no increase in stand and six of the treatments decreased the plant emergence. In the phorate-arasan seed treatment there was no reduction in plant emergence, although a significant reduction in stand was evident 71 days after planting. The Di-syston and American Cyanamid 18706 granular treatments gave a significant reduction in mosaic infection. Both Di-syston and phosphamidon seed treatments caused significant reductions in yields.

An increase in production was evident in the insecticide-treated plots in Tuscola County (Table 3). There was a significant increase in yield where the fertilizer was used as a carrier for the granulated phorate, which was probably a result of the added fertilizer. There was a general increase in yield, although not statistically significant, where the 2-pound rates of granulated phorate and Di-syston and the 1-pound rate of Di-syston were applied. An increase in plant development was especially evident at harvest in the 2-pound Di-syston treatment (Fig. 1). A general retardation was evident during the initial three weeks of plant development in the plots receiving the 2-pound rates of phorate and Di-syston. Similarly, there was a delayed maturity in those beans receiving the higher rates of insecticides.

TABLE 3—Effect of insecticide treatments on plant stands and yields of Sanilac beans, Tuscola County, Michigan, 1959

Material	Formulation	Pounds toxicant per acre	Plants per row-foot	Yield (cwt./acre)
Phorate	10% gran.	1	4.0	12.60
Phorate with fertilizer	10% gran.	1	4.0	16.76*
Phorate	10% gran.	2	4.4	15.09
Di-syston	10% gran.	1	4.6	15.46
Di-syston	10% gran.	2	4.4	15.50
Control	..	..	4.4	12.48
Maximum 5% range(*a*)	..	..	1.5	3.03

(*a*) Maximum range at 95% confidence level from a multiple range test (Duncan 1955).
* Indicates significance from the control at the 5 percent level.

With the exception of the 2-pound per acre application of granulated Di-syston, there was no significant increase or decrease in yield of Michelite beans grown in Saginaw County in 1959 (Table 4). No explanation was evident for the yield reduction in the 2-pound Di-syston plot. There were no significant differences in the plant stands

Fig. 1. The Tuscola County plots on September 9, 1959. Treatment 6 (bottom) was treated with 2 pounds of Di-syston per acre compared with treatment 1 (top), the control.

or yields from the treated plots of cranberry beans in Saginaw County. However, in the dark red kidney plots there was a significant increase in yields where phorate was included with the fertilizer. An increase in vigor was evident in these plants during the entire growing season.

There was no increase in yield as a result of the application of phorate to commercial plantings of yellow-eye and cranberry beans in Montcalm County. However, the cranberry plots had 80 percent reduction in the incidence of virus infection.

TABLE 4—Effects of insecticide treatments on plant stands and yields of field beans, Saginaw County, Michigan, 1959

Material	Formulation	Pounds toxicant per acre	Variety					
			Michelite		Cranberry		Dark red kidney	
			Plants per row-foot	Yield (cwt./-acre)	Plants per row-foot	Yield (cwt./-acre)	Plants per row-foot	Yield (cwt./-acre)
Phorate	10% gran.	1	4.2	29.61	3.1	26.28	2.8	17.80
Phorate with fertilizer	10% gran.	1	4.6	28.72	3.4	26.30	3.4	21.03*
Phorate	10% gran.	2	4.0	29.09	2.8	26.42	2.4	17.76
Di-syston	10% gran.	1	4.3	28.78	3.4	27.69	...	.....
Di-syston	10% gran.	2	4.7	27.69*	3.0	26.34	...	.....
Control	.....	...	4.6	29.85	3.0	25.27	3.3	17.93
Maximum 5% Range(*a*)	.....	...	0.7	2.07	0.8	3.04	1.0	2.22

(*a*) Maximum range at 95% confidence level from a multiple range test (Duncan 1955).
* Indicates significance from the control at the 5 percent level.

Insect population studies were made in the experimental plots during the three-year period. These studies showed that aphids were only occasionally observed. Specimens of the potato leafhopper, *Empoasca fabae* (Harr.), were consistently present during the study. There was a gradual increase in 1959 in the number of potato leafhoppers following plant emergence, with a peak in population occurring the first week of August followed by a gradual decline. Occasional specimens of the six-spotted leafhopper, *Macrosteles fascifrons* (Stal), were present in the plots. There was a general reduction in the numbers of insects present in the plots treated with systemic insecticides. This reduction was evident in those species with migratory habits as well as the more sedentary species.

Residue analysis of Thimet treated snap beans are presented in Table 5. Analyses indicate that there was no detectable phorate residue in snap beans harvested between 62 and 73 days after planting.

TABLE 5—Residue analyses of Kinghorn Special snap beans treated with granular and seed treatments of phorate, 1958

Material	Method of application	Amount of toxicant	Days after planting	p.p.m.(a) phorate
Phorate 44D.....	Seed treatment...	1 lb./100 lb. seed.....	73	N.F.(b)
Phorate 44D+ Arasan 75	Seed treatment ...	2 lb./100 lb. seed + 1 lb. A75/100 lb. seed	63	N.F.
Phorate 2% gran...	In row with seed..	2 lb./acre.....	62	N.F.
Phorate 2% gran.+ Gibberellin gran.	In row with seed..	2 lb./acre	62	N.F.

(a) Calculated as oxygen analog sulfone.
(b) N.F. = None found = less than 0.008 p.p.m.

SUMMARY

Evaluation of the control of bean insects by using systemic insecticides was conducted over a three-year period. Results indicate:

1. The application of the systemic materials directly to the seed often resulted in serious phytotoxicity problems.

2. A 1-pound application of phorate or Di-syston, applied as a granulated formulation, significantly increased yield of snap beans as

TABLE 6—Residue analyses of dried beans treated with phorate, 1959 (a)

Material	Method of application	Pounds of toxicant per acre	Days after planting	p.p.m.(b) phorate
Michelite				
Phorate 10% Granulated...	In row with seed.....	1	113	N.F.(c)
Phorate 10% Granulated...	In row with seed.....	2	113	N.F.
Phorate 10% Granulated...	Banded with fertilizer....	1	113	N.F.
Cranberry				
Phorate 10% Granulated...	In row with seed.....	1	114	N.F.
Phorate 10% Granulated...	In row with seed.....	2	114	N.F.
Phorate 10% Granulated...	Banded with fertilizer....	1	114	N.F.
Dark Red Kidney				
Phorate 10% Granulated...	In row with seed.....	1	113	N.F.
Phorate 10% Granulated...	In row with seed.....	2	113	N.F.
Phorate 10% Granulated...	Banded with fertilizer....	1	113	N.F.
Yellow-Eye				
Phorate 10% Granulated...	Banded with fertilizer....	1	115	N.F.

(a) All residue analyses made by the American Cyanamid Company.
(b) Calculated as oxygen analog sulfone.
(c) N.F. = None Found = Less than 0.005 p.p.m.

well as reducing Mexican bean beetle damage and the incidence of bean mosaic.

3. In the Sanilac, Michelite, and cranberry varieties of field beans, there was no significant increase in the yields resulting from systemic treatments.

4. When granulated phorate was applied with fertilizer to the dark red kidney variety of field beans, there was a significant increase in yield.

5. Snap beans treated with phorate seed treatment as well as granulated formulations had no toxic residues in the harvested product.

6. Field beans treated with phorate granulated formulations had no toxic residues in the dried beans at harvest.

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STRAWBERRY VARIETY TESTING IN MICHIGAN, 1957-1959

By HARRY K. BELL,[1] JOHN D. DOWNES,[2] and R. H. FULTON[3]

THE LEADING STRAWBERRY VARIETIES in Michigan are the older, long-standing ones. They include Robinson, which accounts for 50 to 60 percent, and Premier for 30 to 35 percent of total strawberry production (Keller, 1956, 1957 and 1958). Other varieties found listed in Michigan market reports are: Catskill, Dunlap, Sparkle, Fairland, Dorsett, Jumbo, Armore, Jerseybelle, Aberdeen, Cluster Beauty, Red Cluster, Empire, Tennessee Beauty, Blakemore, Red Glow, Surecrop, Earlidawn, and Pocahontas (Daily Market Report, 1959).

Robinson is the most productive variety. Furthermore, it brings top fresh market prices, mainly because of its large, bright and glossy red berries.

Premier has been a leading variety in Michigan for over 30 years. It ripens early, about a week ahead of Robinson. Its blossoms are more resistant to frost than most varieties and its berries are of a flavor and color, which make them desirable for processing.

Catskill is grown in Northern Michigan for processing. It produces as well as Robinson in the Grand Traverse Bay region, but it is erratic in parts of the State south of there.

Despite their many good features, these standard varieties have several faults. Robinson berries have pale red to whitish centers, unsuited for an attractive frozen product. The foliage is prone to blight and the fruit to stem-end rot. Premier does not produce as heavily as Robinson and its berries become quite small after two or three pickings. The fruit of both Robinson and Premier lack the firmness needed for shipping long distances. Also, the flesh color tends to be pale, detracting from the appearance of the processed product.

It is impossible for growers to test the many new and untried var-

[1] and [2]Assistant professors, department of horticulture.
[3]Formerly assistant professor, department of botany and plant pathology.

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ieties of strawberries listed by nurseries each year. To help Michigan growers evaluate newer varieties, trials have been conducted since 1956 in southwestern Michigan.

MATERIALS AND METHODS

Varieties for evaluation were chosen on the basis of their possibile adaptability to Michigan environmental and marketing conditions. The best plants available were selected for these tests. Whenever possible, plants grown under the Michigan virus-free certification program were used. Row spacing was 3½ feet, and plant spacing within the row 2 feet. Varieties were randomized in each experiment, with three or four replications, except where noted otherwise. Fertilizer was applied as recommended for Michigan strawberry growers. Yield records were taken from either 1 rod or 10 feet of row. All berries which were considered to be marketable were included in these records.

In 1957, yield records were obtained from 15 varieties at the Sodus Experimental Farm and from 30 varieties grown at the C. A. Zollar farm, both located near Sodus, Michigan in Berrien County. In 1958, seven varieties were tested at Sodus and five at the Zollar farm. In 1959, eight varieties were tested at the Sodus farm. A total of 53 different varieties were included in the tests during the three-year period, 1957-59. Of this total, yield records were obtained for 45 different varieties from replicated plots and observations were made on eight varieties not included in the replicated layouts.

Records of berry size were taken in the Zollar test in 1957. This was done by actually counting all of the berries harvested and then dividing this number by the weight. The size data are reported in Table 1 as number of berries to a pound. No size data were taken on any of the other plots, but notations were made whenever a variety produced especially large or small berries.

Since flavor, texture, and color preferences are based upon individual opinions, no attempt was made to rate those factors. If, however, a particular variety was especially superior or inferior in one of these respects, notations were recorded to that effect.

RESULTS

Results of the two trials harvested in 1957 are presented in the order of decreasing yield in Tables 1 and 2. The following varieties

were grown in single plots only, for general observations and the growth and development of the plants: Scarlet Beauty, Red Cluster (Red June), and Cluster Beauty (see bottom of Table 2). Yield data also are presented for these plots but they were not included in the statistical analysis.

A comparison of the two strains of Premier (U.S.D.A. #1 and #2 with the regular Premier; see Table 1) showed them to be different from and inferior in fruit quality and texture to the regular Premier (Howard #17). This has been reported previously (Bell 1955).

TABLE 1—Average yield and size of strawberry varieties at the C. A. Zollar farm near Sodus in Berrien County in 1957

Variety	Yield on an acre basis		Berries per pound
	Pounds	Quarts	Number
Earlidawn	16,874	11,249	49.07
Robinson	12,004	8,003	48.56
Tennessee Beauty	11,204	7,469	81.31
Armore	10,955	7,303	57.99
Empire	10,064	6,709	53.38
Premier (U.S.D.A. 2)	9,022	6,014	57.74
Fairland	8,849	5,899	67.77
Pocahontas	8,591	5,727	58.23
Premier (Howard 17)	8,562	5,708	79.23
Premier (U.S.D.A. 1)	8,199	5,466	64.08
Jumbo	8,177	5,451	77.94
Blakemore	7,429	4,953	72.91
Catskill	7,210	4,807	52.96
Albritton	6,991	4,661	53.92
Sparkle	6,863	4,575	61.23
Plentiful	6,825	5,550	64.70
Wisconsin 214	6,724	4,483	50.39
Jerseybelle	5,934	3,956	43.93
Red Crop	5,459	3,639	66.31
Dunlap	5,383	3,589	80.90
Thomas	5,225	3,483	52.74
Paymaster	4,636	3,091	60.34
Belmar	4,485	2,990	61.33
Superfection	3,986	2,657	75.57
Shasta	3,050	2,033	46.84
Gem	2,514	1,676	72.00
Klondike	1,563	1,042	120.56
Streamliner	1,510	1,007	50.27
Polar Queen	1,397	931	117.92
Aroma	1,374	916	62.33
L.S.D. 5 percent	5,484	3,655	.....
L.S.D. 1 percent	7,234	4,822	.....

TABLE 2—Average yield of strawberry varieties at the Sodus experimental farm near Sodus in Berrien County in 1957

Variety	Yield on an acre basis	
	Pounds	Quarts
Robinson	14,305	9,527
Armore	12,969	8,637
Tennessee Beauty	12,028	8,011
Erie	11,731	7,813
Sparkle	11,286	7,516
Paymaster	11,236	7,483
Dixieland	10,642	7,087
Premier	10,398	6,925
Empire	10,089	6,725
Midland	9,306	6,198
Jerseybelle	8,613	5,736
Albritton	8,266	5,505
Redstar	7,227	4,813
Big Joe	6,583	4,384
Massey	3,910	2,604
L.S.D. 5 percent	2,584	1,722
L.S.D. 1 percent	3,452	2,301
Single plots only:		
Scarlet Beauty	15,565	10,377
Red Cluster (Red June)	13,939	9,293
Cluster Beauty	15,972	10,648

The two variety names, "Sparkle" and "Paymaster", are well established in the nursery trade in Michigan. These tests, however, showed them to be identical in all apparent characteristics.

"Scarlet Beauty" was found to be identical in all respects to "Robinson," and must be considered the same.

The varieties Red Cluster (Red June) and Cluster Beauty produced good crops of berries ripening in the same season as Premier. The fruit of both varieties were soft and not suited for shipping purposes. The berries of Red Cluster were too dark for either the fresh or processing market and their flavor was very flat. Berries of Cluster Beauty, while of good flavor and color, ranged from medium to small in size. The early berries were smaller than those of Premier and none of them were double or split as is the case with the first berries of Premier.

Results of the 1958 trials are presented in Tables 3 and 4. Jumbo, originally included in the Sodus farm plots, was discarded because of the poor stand of plants and production of very small berries.

TABLE 3—Average yield of strawberry varieties at the Sodus experiment farm in 1958

Variety	Yield on an acre basis	
	Pounds	Quarts
Earlidawn	16,652	11,101
Robinson	15,997	10,654
Plentiful	12,164	8,101
S. H. No. 26	12,033	8,014
Vermilion	10,509	6,999
Pocahontas	9,986	6,651
Belmar	9,529	6,346
Blakemore	7,873	5,243
L.S.D. 1 percent	4,748	3,165
L.S.D. 5 percent	3,485	2,323

Jumbo—Discarded due to weak stand of plants and very small berries.

In 1959, tests were confined to promising unnamed selections received from the U. S. Department of Agriculture, Beltsville, Maryland. These were grown in randomized plots with Robinson. Yield records are presented in Table 5.

DISCUSSION

In some cases, there was considerable variation in performance of a variety when comparing the results from one location with those from the other. Also, the variation between plots at a single location was high for certain varieties. These variations are similar to the differences reported by growers for the performance of varieties as they

TABLE 4—Strawberry varieties observed in single plots only at the C. A. Zollar farm in 1958

Variety	Yield on an acre basis	
	Pounds	Quarts
Surecrop	10,940	7,293
Marshall	6,324	4,216
Red Glow	6,191	4,127
William Belt	3,394	2,263
Tahoe	3,202	2,135

TABLE 5—Average yield of strawberry varieties at the Sodus experimental farm in 1959

Variety	Yield on an acre basis	
	Pounds	Quarts
Robinson	11,761	7,841
U. S. 4192	11,755	7,837
Md-US-2555	9,677	6,451
Md-US-2389*	8,575	5,717
Md-US-2601	8,351	5,567
Md-US-2359	6,833	4,555
Md-US-2210	5,700	3,800
Md-US-2610	5,414	3,609
L.S.D. 1 percent	2,881	1,921
L.S.D. 5 percent	2,128	1,419

* Released under the name of "Midway" on December 1, 1959.

evaluate them and may explain in part why so many strawberry varieties are grown in the State. The data in this report are from randomized and replicated plots from which careful records of yield were taken. Thus, they represent relative ratings of the varieties and they may be used as a reasonable index of their producing capacity under southern Michigan conditions.

Varieties for Discard—The following varieties were eliminated from further consideration because they were found not adapted to Michigan conditions: Klondike, Shasta, Massey, Albritton, Midland, Dixieland, Marshall, Tahoe, Polar Queen, Aroma, and Big Joe. Cluster Beauty, Red Cluster, Thomas, Dunlap, Wisconsin 214, Jumbo, Erie, William Belt, and the two strains of U.S.D.A. Premier should be discarded by Michigan growers because they were found to have either poor horticultural characteristics of the fruit and/or the plants. The everbearing varieties, Streamliner, Gem, and Superfection, never have succeeded commercially in Michigan and they did not perform well in this study. S. H. 26 is one of the first promising selections from the strawberry breeding program of the Department of Horticulture of Michigan State University. Its erratic yield record and small berry size has eliminated it for possible introduction as a variety but its good quality of berries makes it valuable as breeding material.

Marginal Varieties—Tennessee Beauty, Armore, and Empire usually are fair to good producers in Michigan and they performed similarly

in this study. They were found to have definite faults, however, which limit their usefulness. Tennessee Beauty berries dropped off in size rapidly after the first two or three pickings. Because of small size, they lacked the eye appeal needed for fresh market outlets, and it was difficult to get pickers to harvest them. Armore was very susceptible to mildew and many of its berries failed to ripen due to reduced leaf surfaces caused by this disease. Empire berries were too soft for shipping and the flesh was too pale for good processing color.

Belmar, Blakemore, and Pocahontas were too erratic in performance to be dependable varieties for Michigan growers. It has been reported by growers that during some years, these varieties produce well in Michigan and in other years, they do poorly.

Red Stele-Resistant Varieties — Where growers have a red stele problem, Sparkle (Paymaster) still appears to be the best all around producer under Michigan conditions. Fairland, Plentiful, Redcrop and Vermilion were found too soft for shipping use, and have already been discarded by most Michigan growers. Surecrop and Red Glow, two new red stele resistant varieties, need further testing in Michigan. Within the limits of this study, they were mediocre in yield. However, both varieties produced firm, large, good quality berries that were well suited for both the fresh and processing markets. Of the two, Surecrop appeared to be the more promising and is suggested for testing by growers where red stele is a problem.

All of the varieties listed in Table 5, except Robinson, are promising red stele-resistant selections from the U. S. Department of Agricultural Experiment Station breeding program. The Md-US-2389 selection was released for propagation to nurserymen December 1, 1959 under the name of Midway (Haut and Cullinan, 1959). Not as productive as Robinson, this variety should be tested only by growers with a red stele problem. None of the other selections in Table 5 are available to growers yet.

Commercial Varieties – Of all the varieties tested, Robinson and Earlidawn were outstanding in these tests. They were among top yielders in every study in which they were included (Tables 1, 2, 3 and 5). Earlidawn, however, has been reported to be highly susceptible to *Verticillium* wilt (Fulton, R. H., 1960). Thus, it should not be grown on land which grew Verticillium-susceptible crops (tomatoes, potatoes, eggplants) during the past three or four years. Where *Verticillium* is not a danger, Earlidawn should be tested by those growers

who want an early variety, either for fresh market or for processing. The berries were found to ripen 3 to 5 days earlier than Premier and the fruit was firmer and held its size better than Premier.

Robinson has been the undisputed leader for fresh market shipping in Michigan during the past 15 years. Its berries, when compared with others, were large, attractive and had fairly tough skins. As in these tests, growers have found that it consistently outyields most other varieties.

Premier still must be considered the most dependable early fresh market variety and the one best suited to processing for Michigan growers. However, if Earlidawn continues to perform well, as found in this study, it could supplant much of the Premier acreage in the next 10 years.

Catskill, while only mediocre in yield when grown in southern Michigan, (Table 1), is a heavy producer in northern parts of the State. It is at its best in the Grand Traverse Bay area, where it is grown for processing purposes.

Very Late Varieties — Of the very late varieties, only Jerseyville and Redstar showed promise. They both were light in yield. They may be grown favorably under irrigation where there is a market for late berries.

SUMMARY AND CONCLUSIONS

Yield and observation of plants and berries were made on 53 strawberry varieties grown in test plots in southwestern Michigan. The long-standing varieties, Robinson and Premier, continued to perform most favorably and appear to be best for most Michigan growers. One recent introduction, Earlidawn, appeared to be outstanding, but the fact that it is highly susceptible to *Verticillium* wilt must be considered when planting. Two new red stele-resistant varieties, Surecrop and Midway, performed fairly well and are suggested for trial where red stele is a problem.

These tests included only those new and long-standing varieties which appeared most promising for Michigan. New varieties will continue to be tested as they are introduced.

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STUDIES IN WHITE PINE SEEDLING ROOT ROT[1, 2]

By JERRY W. RIFFLE[3] and FORREST C. STRONG

DEPARTMENT OF BOTANY AND PLANT PATHOLOGY

INTRODUCTION

A REVIEW OF THE PRODUCTION records of the U. S. Forest Service Chittenden Nursery, established in 1934 at Wellston, Michigan, shows that there have been consistent losses in the white pine beds. The losses at first were attributed to white grubs, but in 1948, a root rot disease was recognized in the 2-1 and 2-2 white pine transplant beds, and a large number of trees were lost in both ages of stock. There was no evidence at this time of white grub injury on the majority of the transplants that had died. In 1949 the root rot disease was extremely serious when most 1-0 white pine seedlings were killed and heavy losses occurred in the 2-0, 2-1, and 2-2 beds.[4]

Since 1952 various experiments have been carried out in an effort to control the root rot disease. Results of tests up through 1956 by the Lake States Forest Experiment Station[5] involving over 500,000 white pine seedlings indicate the following:

1. Methyl bromide applied at the rate of 2 pounds per 100 square feet, supplemented with a zineb (zinc ethylene bisdithio-carbamate) foliage spray, has increased seedling production by as much as 150 percent over that of untreated beds.

2. Formaldehyde (40 percent commercial) applied at 1.5 ounces per square foot has given excellent control of the root rot disease.

[1]These research studies were supported in part by a grant of $2,400. from the U.S. Forest Service. In addition, facilities were provided at the Chittenden Nursery, and certain supplies and labor funds were furnished by the U. S. Forest Service.

[2]Special thanks are extended to Dr. Ralph L. Anderson of the Lake States Forest Experiment Station and to E. D. Clifford, Superintendent of Chittenden Nursery, who gave suggestions and aid in conducting this study and reviewed and approved the results presented in this paper.

[3]Present address: Jerry W. Riffle, Department of Plant Pathology, Univ. of Wisconsin, Madison, Wis.

[4]Clifford, E. D. (1954). Synopsis of past work on white pine root rot at the Chittenden Nursery. Mimeographed.

[5]Anderson, R. L., D. D. Skilling, and E. D. Clifford (1956). Nursery root disease control by soil fumigation. Lake States Forest Expt. Sta. Tech. Notes No. 449.

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3. Use of methyl bromide and formaldehyde has resulted in heavier seedlings even though there was a denser stand in these beds.

Further progress in control of this disease required more exact knowledge of the etiology.

This paper reports on studies initiated in June, 1957 to determine the actual cause of the root rot disease, and continued through August, 1958. Inoculation tests were made to determine pathogenicity of a suspected organism.

Symptoms of the disease

Root rot occurs on white pine nursery stock of all ages, from 1-0 seedlings to 2-2 transplants, throughout the nursery. Healthy and affected trees in all stages of decline may be found intermixed in the white pine beds in the nursery. The aboveground symptoms of root rot are chlorosis and stunting of foliage, and a stunting of the tree itself. Stunting and chlorosis of foliage appear to progress from the top of the seedling downward. The color of the foliage changes from a dark bluish green to a color ranging from a pale green to a light yellow. The color change starts on the extreme tips of the needles and advances toward their base. Later the needles dry and turn brownish-red, from the tip downward. The seedling dies in an upright position after the bark and cambium are killed, (Fig. 1).

Underground symptoms of the root rot are characterized first by a rotting of the small rootlets, soon followed by the rotting of the lower portion of the primary root. Some of the lateral roots of healthy appearing trees have root rot symptoms. The cortex is sloughed off from the affected lateral roots as they become well decomposed with the advance of the disease. The epidermis appears to turn from a light tan to black. The root rot progresses from the young tissues of the root toward the older tissues and proliferation occurs above the rotted portions of the lateral roots. Later, portions of the lateral roots and primary roots completely slough off leaving only a small part of the root system. Trees at this stage of decline are sustained by a few lateral roots in the upper few inches of the soil.

MATERIALS AND METHODS

Isolation and Identification of microorganisms

The isolation and identification of microorganisms from white pine seedlings showing symptoms of the root rot disease were initiated in

(Photograph, courtesy U. S. Forest Service).

Fig. 1. Stages of root rot symptoms on 2-2 white pine transplants. Healthy transplant on left, diseased transplant in middle, and dead transplant at right.

June, 1957 at the U. S. Forest Service Chittenden Nursery at Wellston, Michigan. Working on the premise that a soil inhabiting fungus might be the cause of the root rot, tissue plantings were made from the roots of white pine seedlings in various stages of decline. The root systems of the nursery stock selected for tissue plantings were thoroughly washed in flowing tap water in order to remove excess soil and other foreign matter. Roots showing early stages of browning were selected and cut into sections approximately one-quarter to one-half inch in length.

Seventy percent ethyl alcohol was used as a surface sterilizing agent. Each root section was immersed in this solution for approximately 1 minute and then aseptically transferred to a bath of sterile distilled water before planting aseptically with forceps in sterile medium in a Petri plate. The principal medium used was potato dextrose agar (PDA) acidified with 25 percent lactic acid.

Colonies growing from each tissue planting were identified to genus by examining them under a compound microscope. The fungi

that did not sporulate were transferred to PDA slants for later identification. The frequency of microorganisms isolated from 1832 diseased white pine seedlings is shown in Table 1.

TABLE 1—Frequency of microorganisms isolated from white pine nursery seedlings showing various degrees of root rot(a)

Micro-organisms isolated	Number of times isolated	Percentage(b)	Micro-organisms isolated	Number of times isolated	Percentage(b)
Fusarium.....	565	30.84	Rhizoctonia.....	9	0.49
Penicillium.....	154	8.41	Verticillium.....	5	0.27
Trichoderma.....	122	6.66	Aspergillus.....	4	0.22
Rhizopus.....	121	6.60	Chaetomium.....	3	0.16
Bacteria.....	75	4.09	Botrytis.....	2	0.11
None (sterile).....	54	2.95	Cephalothecium...	2	0.11
Hormiscium.....	25	1.36	Curvularia.....	1	0.05
Alternaria.....	20	1.09	Phoma.....	1	0.05
Zygorhynchus.....	15	0.82	Non-sporulators...	654	35.70

(a) Isolations from 1832 diseased white pine seedlings from June to September of 1957 and June to September of 1958.
(b) Expressed as percentage of total isolations.

Greenhouse Inoculation Technique

Five different *Fusarium* isolates, *F. solani* (No. 33), *F. moniliforme* (No. 42), *F. solani* (No. 46), *F. moniliforme* (No. 49), and *F. oxysporum* (No. 62) identified to species by Dr. William C. Snyder, Professor of Plant Pathology, University of California, were selected at random from the large collection of pure culture isolates of 1957. The isolates were grown on a medium consisting of cornmeal plus vermiculite and on a synthetic liquid medium. The cornmeal-vermiculite medium was prepared by mixing 130 ml. yellow cornmeal in a 1-liter Erlenmeyer flask with 130 ml. each of water and vermiculite. These materials were thoroughly mixed, autoclaved, cooled, and each flask seeded with one of the selected *Fusarium* pure culture isolates. Unplanted flasks served as control inoculum. The synthetic liquid medium had the following composition: 1 liter distilled water, 7.2 grams sucrose, 3.6 grams dextrose, 1.23 grams magnesium sulfate, 2.72 grams KH_2PO_4, and 2.02 grams KNO_3[6]. Each of these flasks was planted with one of the selected *Fusarium* pure culture isolates. Unplanted flasks served as control inoculum.

[6]Rawlings, T. E. (1933). *Phytopathological and Botanical Research Methods.* John Wiley, New York. 156 p.

Pure sand to be infested with inoculum was obtained from a gravel pit approximately 5 miles from the nursery. It was collected at a depth of 35 feet below the ground level. Danger of introducing a root rot pathogen from this source was considered to be negligible because of the very low organic matter content of the sand. The inoculum, consisting of the contents of one Erlenmeyer flask, was placed on the sand surface in the greenhouse flat, broken into small pieces, and mixed thoroughly by hand. A metal divider was placed in the flat to separate it into two equal parts. One-half of the flat was planted with 100 white pine seed from the 1956 crop. The other half was planted with 50 healthy white pine woodsplot seedlings collected at the Chittenden Nursery. This woodsplot, near the border of the nursery, was established in 1954 and planted with white pine seed in 1955, 1956, and 1958. No root rot has ever developed in this plot.

In infesting seedlings with the inoculum grown on the synthetic liquid medium, the surface mycelial mats were macerated in a Waring blendor. Then the mycelial fragments and spores were suspended in the liquid medium and sprayed on the surface of the sand in the flat with a rubber bulb sprayer.

Two greenhouse inoculation series were used. The first series, established in September 1957, consisted of 10 flats as follows: a control flat containing uninoculated synthetic liquid medium (PLM), and one containing uninoculated cornmeal-vermiculite medium (CCV), a control flat with no media or inoculum added (CNM), a flat containing synthetic liquid medium on which the *Fusarium* isolates were grown (LFM), and one containing a mixture of the *Fusarium* mycelial mats (FMM), one flat with a *F. oxysporum* isolate, two flats each containing a different *F. solani* isolate, and two flats each containing a different *F. moniliforme* isolate. When seedlings in these flats become discolored and appeared to be infected, they were removed for isolation purposes.

A second similar greenhouse series was established in December, 1957. The same inocula and procedures were employed in this series as the former with the following exceptions: the same type of soil was used but it was previously steam sterilized for 2 hours, the white pine seed was surface sterilized with mercuric chloride (1:3000), the synthetic liquid medium on which the *Fusarium* mats were grown (LFM) was omitted and an additional control flat containing no medium or inoculum was used to take its place. The second greenhouse series thus consisted of 10 flats.

DISCUSSION OF RESULTS

Isolation Studies

Isolations of microorganisms from white pine nursery stock were carried out during the summer of 1957 and 1958, and the results are shown in Table 1. It lists the microorganisms isolated from white pine nursery stock and indicates the frequency with which each organism appeared.

Isolations from the advanced margins of lesions on white pine affected with root rot in varying degrees produced a number of microorganisms. *Fusarium* was the predominant organism isolated from root tissue, being found on 30.8 percent of the 1832 tissue plantings. *Fusarium* was isolated nearly three times as often as the next three highest identifiable fungi; namely, *Penicillium*, *Trichoderma*, and *Rhizopus*.

The frequency of isolation of *Fusarium* species from white pine seedlings of different age stocks is shown in Table 2. *Fusarium* species were found on 30.0, 33.7, 36.1, and 5.4 percent, respectively, of the 1-0, 2-0, 2-1, and 2-2 stock examined. The low frequency of *Fusarium* in the 2-2 stock may be due to the age and increased vigor of the host or to the earlier elimination of the more susceptible plants. Another factor may be the increase in frequency of *Trichoderma* in the 2-2 iso-

TABLE 2—Frequency of microorganisms isolated from white pine nursery seedlings of different ages

Microorganisms isolated	Percentage of isolates from plants of			
	1-0 Stock(a)	2-0 Stock	2-1 Stock	2-2 Stock
Fusarium	30.00	33.70	36.14	5.44
Penicillium	1.92	7.20	5.94	17.69
Trichoderma	4.23	7.39	2.97	14.28
Rhizopus	10.38	4.71	10.40	11.56
Bacteria	0.38	2.77	7.92	15.65
Rhizoctonia	2.31	0.09	0.00	0.68
None (sterile)	6.15	2.22	0.49	2.72
Hormiscium	0.00	0.00	9.41	4.08
Alternaria	1.54	0.74	2.48	1.36
Others	0.00	1.44	0.49	3.40
Non-sporulators	43.77	39.24	23.76	23.13
Number of seedlings examined	260	1,083	202	147

(a) The first figure refers to the number of years the seedling was grown in the seedbed and the second refers to the number of years it was grown in the transplant bed.

lations. It has been established[7] that various *Trichoderma* species inhibit parasitic fungi. The frequency of *Penicillium* species and bacteria increased with the age of the stock. This increase in saprophytes may be due to an increase in dead tissue sloughed off by the older roots and to the difficulty of adequately disinfecting the surface of the older root sections.

Since it has been established by others[8, 9, 10] that some *Fusarium* species are able to cause damping off and root rot of various plants, and since *Fusarium* was isolated more commonly than other fungi, it was desirable to test its pathogenicity on white pine seedlings.

Inoculation Studies

Five different *Fusarium* isolates were used in two separate inoculation tests in the greenhouse. The microorganisms reisolated from the seedlings which became diseased when grown in the infested soil are shown in Tables 3 and 4.

Fusarium species were the principal microorganisms reisolated from 626 diseased white pine seedlings of the two greenhouse tests. These seedlings were grown in soil to which isolates of *Fusarium* were added. In the first test 82.35 percent of the reisolates from diseased plants developing in infested soil were *Fusarium*. In the flats containing the controls, 29.67 percent *Fusarium* was obtained from reisolations. Infection in the control flats was probably due to air or insect borne spores as these flats stood next to those containing infested soil.

Since 82.35 percent of the reisolations from diseased seedlings in infested soil were *Fusarium*, and 29.67 percent *Fusarium* isolations were obtained from control flats, then the difference of 52.68 percent must be accounted for by the deliberate infestation of the soil with *Fusarium* isolates (Table 3). The corresponding value due to the inoculation in the second greenhouse test was 60.25 percent (Table 4).

Fusarium oxysporum was the most pathogenic individual inoculum used, being recovered from 90 percent of the infected seedlings.

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[7]Vaartaja O. (1958). Effects of *Trichoderma* on tree seedlings and their pathogens. Bi-m Progr. Rept. Div. For. Biol. Dept. Agr. Can. 13:1.

[8]Gifford, C. M. (1911). The damping-off of coniferous seedlings. Vt. Agr. Expt. Sta. Bul. *157*: 141-171.

[9]Hartley, C., T. C. Merrill and A. S. Rhoads (1918). Seedling diseases of conifers. Jour. Agr. Res. *15*: 521-558.

[10]Spaulding, P. (1907). A blight disease of young conifers. Science. n.s. *26*: 220-221.

TABLE 3—Frequency of microorganisms reisolated from white pine seedlings grown in soil in the first greenhouse series

Source of inoculum	Infestations									Controls				
	33	42	46	49	62	FFM (*a*)	LFM (*b*)	Total	Percentage	PLM (*c*)	CCV (*d*)	CNM (*e*)	Total	Percentage
No. of plants used for reisolation.....	34	30	36	39	25	41	33	238	..	39	6	46	91	..
Micro-organisms isolated														
Fusarium....	29	24	35	35	22	37	14	196	82.35	14	4	9	27	29.67
Others(*f*)....	5	6	1	4	3	4	19	42	17.65	25	2	37	64	70.33

(*a*) Isolated numbers 33, 42, 46, 49 and 62 grown on synthetic liquid medium and their mycelial mats combined and used as inoculum.
(*b*) Liquid from the five Fusarium isolates as above grown on synthetic liquid medium.
(*c*) Check containing the unplanted synthetic liquid medium.
(*d*) Check containing the unplanted cornmeal vermiculite medium.
(*e*) Control without any medium or inoculum added.
(*f*) Includes the microorganisms with their respective percentages for the infected plants: Penicillium 5.88 None (sterile) 5.46 Non-sporulators 2.52, Verticillium 2.10, Rhizopus 0.84, Alternaria 0.42 and Bacteria 0.42.
Includes the following microorganisms with their respective percentages for the control plants: Penicillium 38.46, None (sterile) 9.89, Verticillium 8.79, Non-sporulators 6.59, Bacteria 4.39, Trichoderma 1.10 and Aspergillus 1.10.

TABLE 4—Frequency of microorganisms reisolated from white pine seedlings grown in soil in the second greenhouse series

Source of Inoculum	Infestations								Controls				
	33	42	46	49	62	FMM (*a*)	Total	Percentage	PLM (*b*)	CCV (*c*)	CNM (*d*)	Total	Percentage
No. of plants used for reisolation.....	67	60	69	64	62	66	388	.....	61	59	123	243	.....
Microorganisms isolated Fusarium..	61	55	54	58	57	59	344	88.66	20	34	15	69	28.40
Others(*e*).....	6	5	15	6	5	7	44	11.34	41	25	108	174	71.60

(*a*) Isolate numbers 33, 42, 46, 49 and 62 grown on synthetic liquid medium and their mycelial mats combined and used as inoculum.
(*b*) Check containing the unplanted synthetic liquid medium.
(*c*) Check containing the unplanted cornmeal vermiculite medium.
(*d*) Control without any medium or inoculum added.
(*e*) Includes the following microorganisms with their respective percentages for the infected plants: None (sterile) 4.38, Verticillium 2.58, Penicillium 2.06, Bacteria 0.77, Trichoderma 0.51, Aspergillus 0.51, Alternaria 0.26, and Non-sporulators 0.26.
Includes the following microorganisms with their respective percentages for the control plants: Penicillium 22.63, None (sterile) 19.75, Non-sporulators 10.28, Verticillium 8.23, Trichoderma 4.53, Botrytis 2.06, Rhizopus 1.65, Bacteria 1.65, and Aspergillus 0.82.

SUMMARY

Root rot of white pine seedlings and transplants was studied from June 1957 to September 1958 at the Chittenden U.S. Forest Service Nursery in Wellston, Michigan, and during the fall and winter in the Plant Science Greenhouse at Michigan State University.

Fusarium species comprised 30.8 percent of all of the microorganisms isolated from 1832 diseased white pine seedlings at the Nursery and appeared nearly three times as often as the next three highest identifiable fungi.

The frequency of isolation of *Fusarium* species from diseased white pine seedlings increased with age of the stock from 1-0, 2-0, and 2-1 plants, then decreased markedly from the 2-2 plants, while the frequency of isolations of *Trichoderma, Penicillium,* and bacteria increased considerably from the 2-2 stock.

The percentage recovery of *Fusarium* from diseased plants due to soil infestation in the first inoculation test, was 52.68 percent while the corresponding figure from the second inoculation series was 60.26 percent.

EFFECTIVENESS OF SOME HERBICIDES IN KILLING YOUNG RED MAPLE

By MAURICE W. DAY

DUNBAR FOREST EXPERIMENT STATION

MUCH PROGRESS has been made recently in methods of killing undesirable trees in forest stands, but much more remains to be learned. The development of efficient control methods for hardwood species depends upon learning more about their reactions to specific chemical formulations. This study is concerned with the effect of six different herbicide formulations applied by a variation of injection method to red maple (*Acer rubrum* L.).

Elwell[1] has described the injection method as being the use of a mechanical device to place a small amount of herbicide solution under the bark, or a short distance into the wood. Undiluted or very strong solutions permit use of only small amounts of liquid, and make the method superior in this respect to basal spraying or even frill-girdling and spraying. Cook[2] also has described a similar method of efficiently applying sodium arsenite, and similar methods may be applicable with some other herbicides.

A number of workers have experimented with the use of undiluted herbicide formulations applied to cuts in the bark and wood of trees for the purpose of killing them. Results have generally been encouraging, but many differences due to variations in climate and species response have been evident. Leonard,[3] working with some California species, had the best results when the bark was completely severed, but cuts spaced at six inches apart and treated with 4 ml. each gave good kills when treated during the late fall and winter. The amines of 2,4-D and 2,4,5-T gave the best results. Westing[4] used undiluted

[1]Elwell, Harry (1956). Injection method for tree and brush control, North Central Weed Control Conference 13:69-70.

[2]Cook, David B. (1959). The hatchet and oil can technique for the application of sodium arsenite. Jour. of Forestry 57:845-847.

[3]Leonard, O. A. (1957). Effect of phenoxy herbicide concentrates applied to cuts of sprouting tree species. Weeds 5:291-303.

[4]Westing, Arthur H. (1955). Effect of undiluted 2,4-D and 2,4,5-T on cut surfaces of Oak in Lower Michigan. North Central Weed Control Conference, Research Report 12, page 68.

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amines and esters of 2,4-D and 2,4,5-T on red and white oak in Lower Michigan at rates of ½, 1, and 2 ml. per inch of diameter, in full and partial frill girdles. The amine of 2,4-D proved most effective.

PROCEDURE

Over 300 maple stems were selected for the study and each was measured, tagged, and recorded. The stems were classified into 1-inch d.b.h. classes and divided into groups of 10. Practically all stems used were within the 2-, 3-, and 4-inch d.b.h. classes. A mallet and a 1-inch wood chisel were used to make a slanting cut into the stem about 1 foot from the ground line. Each cut was made deep enough to hold at least one ml. of solution without overflowing. The herbicide solution was placed in the cut with a medicine dropper. Additional cuts were made for larger doses. A group of 10 stems was used for each treatment.

HERBICIDES USED

Some of the herbicides used were new ones believed to have promise for this kind of work. Others were more or less standard formulations useful for comparative purposes.

The herbicides used were as follows:

1. Amitrol (2 lbs. 3-amino-1, 2, 4-triazole per gal.)
2. Amitrol plus PBA (1 lb. 3-amino-1,2,4-triazole, plus 4 lbs. polychlorobenzoic acid equivalent, as dimethylamine salt, per gal.)
3. 2,4-D (4 lbs. acid equivalent, as alkanolamine salt, per gal.)
4. 2,4,5-T (4 lbs. acid equivalent, as triethylamine salt, per gal.)
5. 2,4,5-T LV (4 lbs. acid equivalent, as low-volatile propylene glycol butyl ether ester, per gal.)
6. PBA (4 lbs. of polychlorobenzoic acid equivalent, as dimethylamine salt, per gal.)

Throughout the rest of this report the herbicides will be referred to by the common name preceding the chemical designation in parentheses. All materials were used without dilution. Treatments were applied during late June, 1958, and the trees examined two weeks, eight weeks, and 13 months later. Evaluation of the effectiveness of the treatments in killing the trees was based mainly on the final

examination. A numerical rating system was used for evaluating the results, making it possible to give effectiveness in percent, with 100 percent indicating a complete kill of the tree crown.

RESULTS AND DISCUSSION

The first examination, two weeks after treatment, showed remarkable effects rfom 2, 4, 5-T. Most of the trees treated with this chemical had completely dead leaves, but those treated with the other herbicides showed much less evidence of having been treated. Examination eight weeks after treatment showed continual superiority of 2,4,5-T, but the heavier dosages of amitrol plus PBA also showed good results. Results with amitrol, 2,4-D, 2,4,5-TLV, and PBA were rather erratic, with much evidence of treatment but little definite killing of the trees.

The examination made 13 months after treatment showed quite different results from those made earlier. Formulations containing PBA showed much better kills, indicating a slower action which, from past experience, usually means a better kill with less sprouting.

Results observed at the final examination, 13 months after treatment, are shown in Table 1.

Although the data do not cover the complete range of tree sizes or dosages, it appears that the minimum effective dosage has been obtained in the 2-inch class. However, since all dosages of PBA produced a 100-percent kill of 2-inch trees, it is possible that the minimum dosage for this chemical may be even lower than the lowest used in this study. Similarly, with amitrol and 2,4-D the minimum effective dosage

TABLE 1—Effectiveness of treatments in percent of trees crown-killed

Dosage Ml. per D.B.H. class, inches	Number of formulation					
	Amitrol	Amitrol plus PBA	2, 4-D	2, 4, 5-T	2, 4, 5-T LV	PBA
½ per 3				78		
½ per 2				94		
1 per 3	24	72	28	90	22	
1 per 2	32	88	40	100	52	100
2 per 3		92				
2 per 2	76	88	66	100	94	100
3 per 3	92	100		100	92	
4 per 2	92	96	98	100		100
4 per 4					98	

may well lie between 2 and 4 ml., rather than at 4 ml. If 85 percent or better of complete crown kill is taken as an acceptable level of effectiveness, the minimum dosages for trees in the 2-inch d.b.h. class are as follows:

Formulation number	Dosage, ml.
Amitrol	4 (or less)
Amitrol plus PBA	1
2,4-D	4 (or less)
2, 4, 5-T	½
2, 4, 5-T LV	2
PBA	1 (or less)

In the larger diameters, the data do not show clearly the minimum dosages needed. Further work will be necessary to determine the relationship between size of tree and dosage required.

The final examination showed several instances of adjacent red maple stems being killed in addition to the treated trees. Some of these adjacent stems were stump sprouts which were plainly joined with the treated tree. A few appeared to be independent stems of seedling origin. The root system of one of these untreated dead stems was excavated and a graft of a root about the diameter of a pencil with a root of a treated tree was discovered. This had apparently caused the death of a 2-inch stem about 3 feet from the treated tree. In all except four instances involving 2,4,5-T, adjacent trees killed were those treated with formulations containing PBA. This would indicate more root effect with PBA than with the others.

The results obtained indicate that further consideration should be be given to the use of the injection method for controlling red maple, and, possibly, similar hardwood species.

SUMMARY

More than 300 red maple saplings, mostly 2 to 4 inches in diameter, were treated with undiluted specified amounts of six different herbicides placed in 1-inch cuts made at 1 foot above the ground. All of the herbicides were effective in killing the saplings with at least one of the dosages used. Minimum effective dosages for 2-inch stems ranged from ½ to 4 ml. Differences in rate of kill and root effect upon adjacent trees were noted. Results indicate that the injection method,

or some variation of it, may be suitable for killing red maple, with some of the herbicides used. The amine salt of 2,4,5-T and the PBA gave the best results of all the herbicides. Further work is needed to determine minimum dosages of these and similar formulations for killing larger trees.

STRAWBERRY PURCHASES[1]

Purchase Trends and Characteristics of Purchasers

By CARLETON C. DENNIS
DEPARTMENT OF AGRICULTURAL ECONOMICS

PRODUCTION AND MARKETING DECISIONS are constantly being made by every industry. These decisions are based on the best and most recent data available. This report concerns a study conducted to add to the information which can be used by the strawberry industry.

Data were obtained through the M.S.U. Consumer Panel.[2] They were analyzed to determine the association between selected individual and family characteristics and purchases of fresh and frozen strawberries. Use of home-grown strawberries and strawberries received as gifts was omitted because decisions of commercial strawberry producers are based on sales as represented by consumer purchases rather than on total strawberry consumption.

Strawberry consumption has varied greatly over the last 40 years. The average annual consumption in the U. S. was more than 4 pounds per person during the 1920's. In the early 1930's this decreased to a low of 2.9 pounds in 1935. A gradual increase followed until 1942, when the effect of World War II began to be felt. Strawberry production was drastically curtailed to a low per capita consumption of 1.5 pounds in 1944. After the war, production, and per capita consumption, began a strong and steady recovery. This was aided considerably by increased use of freezing which extended the potential annual consuming period for most of our population from a few weeks to 12 months.

Post-war per capita consumption of fresh and frozen strawberries in the U.S. is shown in Fig. 1. The solid line in this figure represents

[1]M.S.U. Consumer Panel Report No. 56.

[2]This report is based primarily upon data obtained through the Mich. State Univ. Consumer Panel and includes that for 1953 through 1958. The panel consisted of a sample of about 250 families in the Lansing, Michigan, area, selected as representative of residents of a city of about 100,000 population. Each week the panel families reported in an itemized diary the quantity, price and expenditure for each item purchased during the week for home consumption.

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average U.S. per capita consumption of frozen strawberries in processed weight. The light dashed line represents the average U.S. per capita consumption of fresh strawberries. Annual fresh strawberry consumption decreased while frozen strawberry consumption increased during this period. Frozen exceeded fresh consumption for the first time in 1954. Fresh strawberry consumption reached a low of 1.2 pounds per person in 1955 but has since increased, while frozen consumption has leveled off in recent years. If frozen strawberry weights were given in fresh equivalents, consumption would appear to be somewhat less. It would be approximately equal to fresh consumption in 1955 and less than fresh consumption in all other years.

The relationship of M.S.U. Consumer Panel per capita purchases to U.S. per capita consumption also is shown in Fig. 1. Per capita frozen strawberry purchases of the panel were approximately equal to U.S. consumption, although the panel purchases showed greater annual variation. This variation was not unexpected, since we usually find a smaller average variation in a whole than in its parts. However, the apparent equality of the panel per capita purchases and U.S. per

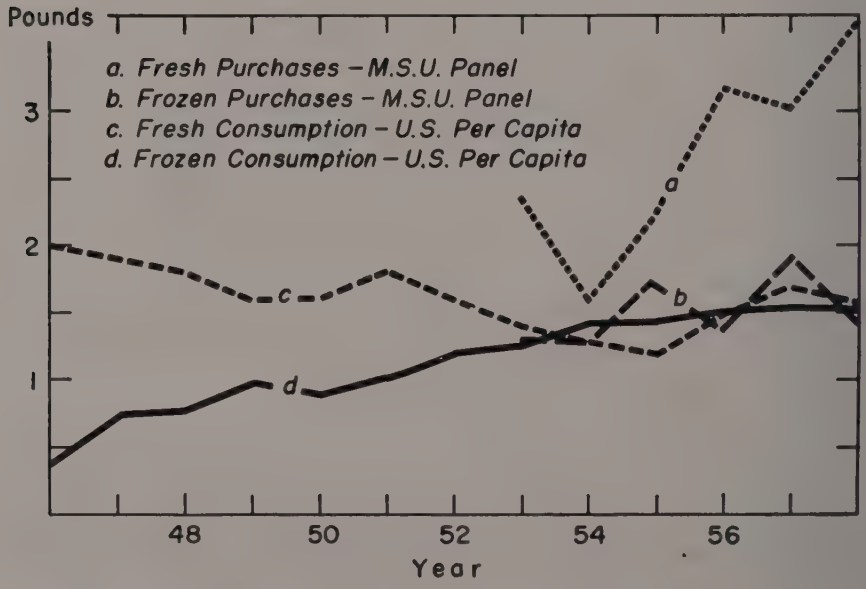

Fig. 1. Comparison of U.S. per capita consumption and M.S.U. Consumer Panel per capita purchases of fresh and frozen strawberries. Source: U.S. data taken from Tables 11 and 14 of supplements for 1956 and 1958 to "Consumption of Food in the United States, 1909-1952."

capita consumption is misleading. Only about half of the total U.S. frozen strawberry pack is in retail-size containers, the remainder being in large containers for institutional and manufacturing uses. Panel purchases are almost exclusively of retail-size containers. Therefore, on a per capita basis, they are considerably greater than the U.S. average consumption of this product.

The panel per capita fresh strawberry purchases do not have a close correspondence to U.S. per capita consumption. Average annual increases and variations were much greater in Lansing than in the U.S. in 1953-58. The variation can be explained on the same basis as for frozen strawberries. The greater increase in Lansing than in the U.S. probably is due to a large extent to the rapid increase in local fresh strawberry production. Michigan fresh strawberry production doubled from 1954 to 1957.

Seasonal Variation in Purchases

The pattern of seasonal variation in strawberry purchases has changed since freezing became important in the strawberry industry. This is demonstrated in Fig. 2, where the weekly percentages of annual strawberry purchases in fresh and frozen form are shown. Seventy-two percent of all fresh strawberry purchases occurred in the 24th through the 27th week. Expansion of this period to the 22nd through the 28th week would include over 86 percent of the annual purchases. Weekly purchases exceeded 1 percent of the total annual fresh strawberry purchases in only 11 weeks.

Frozen strawberries have tended to even out the strawberry purchase pattern. Frozen purchases were largest in the early part of the year, reaching a peak about April 1. This declined somewhat until the 19th week, when a steady decrease started and continued until it reached a low in the 26th week, one week after the fresh purchases reached their peak. Frozen purchases did not increase significantly through the summer and fall, even though fresh purchases returned to nearly zero. Although availability of fresh fruits and other berries undoubtedly decreased the demand for frozen strawberries in summer months, it seems likely that the large quantity of strawberries purchased during the short fresh strawberry harvest season to a large extent fulfilled the desire for strawberries for a considerable period. The weekly purchase of frozen strawberries more than doubled between the first and 13th weeks of the year.

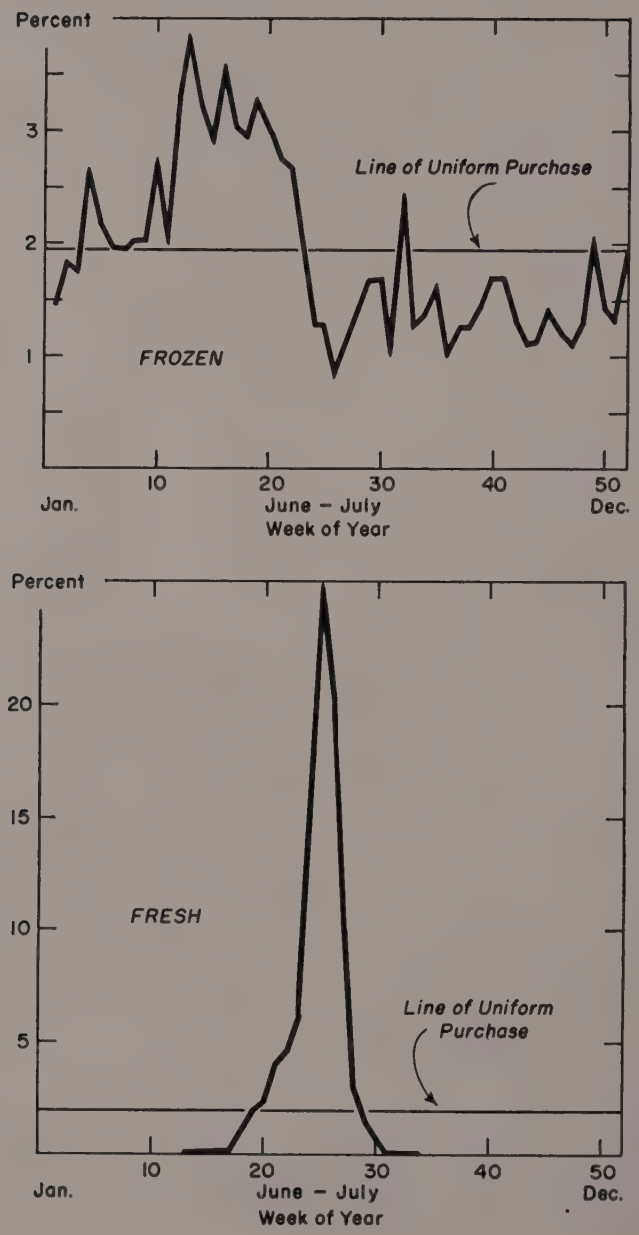

Fig. 2. Percent of annual fresh and frozen strawberrries purchased in each week, 1953-58, by members of the M.S.U. Consumer Panel.

Per Capita and Per Family Purchases

Panel A in Fig. 3 gives the cumulative distribution of fresh and frozen strawberry purchases. The cumulative percent of total families is given on the vertical axis. A large percentage of both fresh and frozen strawberry purchases occurred in a comparatively small percent of the families. For instance, 20 percent of the fresh strawberry purchases were made by less than 4 percent of the families. If the purchase percentage is increased to 50, the family percentage is increased to only 16. An average of 20 percent of the families did not purchase fresh strawberries during the entire year. Frozen strawberry purchases, shown in Fig. 3, were made by an even smaller percentage of the families, with 100 percent of the purchases being made by 63 percent of the families.

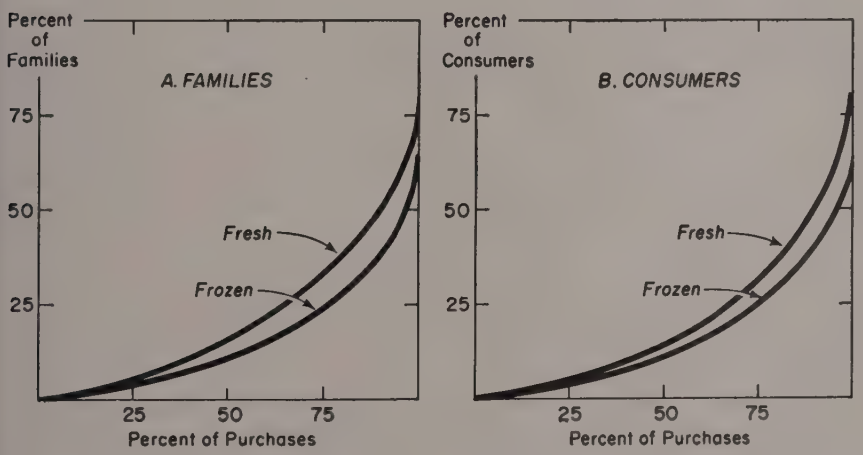

Fig. 3. Cumulative distribution (low to high) of fresh and frozen strawberry purchases with respect to families and consumers among Michigan State University Consumer Panel members, 1953-58.

The small quantities of strawberries purchased by many families is a corollary of the fact that these families purchase strawberries a very few times each year. In analyzing purchases made by M.S.U. Consumer Panel members in 1955 and 1956, Shaffer[3] found that the average family purchased fresh strawberries in 3.1 weeks per year and frozen strawberries in 3.0 weeks. Only 2 percent purchased fresh strawberries

[3]Shaffer, James D. (1958). Frequency of Purchase of Major Fresh, Frozen, and Canned Fruits and Vegetables, Quarterly Bulletin of the Michigan Agricultural Experiment Station, Michigan State University, East Lansing, Vol. 41, No. 1, Table 1, p. 38.

and 5 percent frozen strawberries more than 10 weeks of the year. Twenty percent purchased fresh and 16 percent purchased frozen strawberries more than five weeks of the year.

Family purchases have been assigned equally among family members to place purchases on a per consumer basis in Panel B of Fig. 3 and the purchase distribution is much the same as on a family basis. Fifty percent of fresh strawberry purchases are made in families representing only 14 percent of the consumers and almost 80 percent are required to absorb 100 percent of the purchases. There is a slightly greater difference in the frozen strawberry purchase pattern, where 66 percent of the consumers were in families making 100 percent of the purchases.

Income

Family income exerts different influences on fresh and frozen strawberry purchases (Fig. 4). Annual fresh strawberry purchases in-

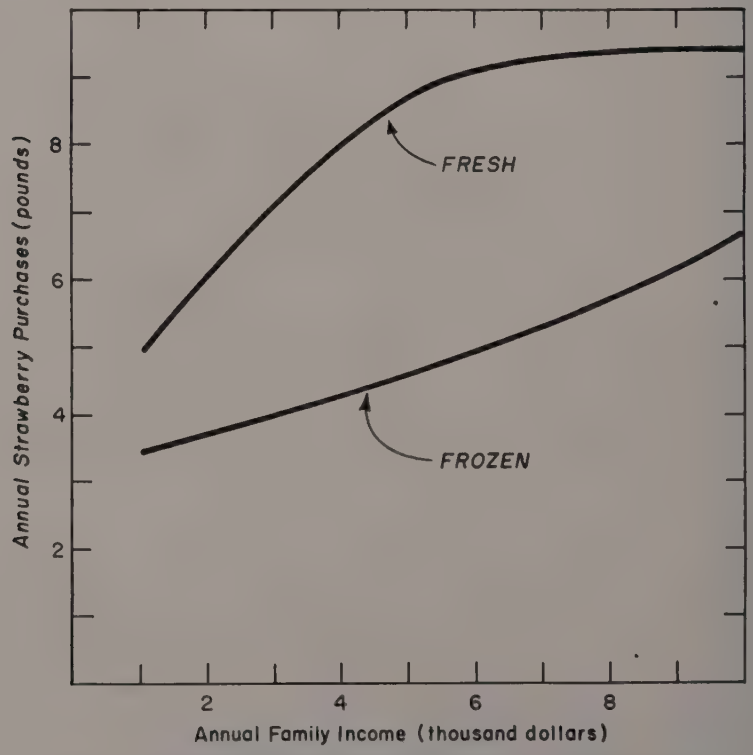

Fig. 4. Relation between annual strawberry purchases and annual family income.

crease rapidly with income in the range up to about $5,000. Purchases seem to level off at about this point, however, and are not much larger at $10,000 than at $5,000. Frozen purchases per family are lower than fresh purchases at any given income level. Furthermore, the influence of family income on annual purchases of frozen strawberries is quite different than on purchases of fresh ones. Annual purchases of fresh and frozen strawberries are most nearly equal in the families with lower incomes. While fresh purchases increase rapidly with income in the lower income range and then level off, frozen purchases increase comparatively slowly over the entire income range. The greatest difference in fresh and frozen purchases per family occurs in families with incomes of $5,000 to $6,000.

Family Size

Family size, as might be expected, has some effect on strawberry purchases. The effect, however, on fresh strawberry purchase is rather small, as can be seen in Fig. 5. If, for instance, family size is increased from two to four persons, annual fresh strawberry purchase is increased only from 8 to 8½ pounds, a 100 percent increase in family size and less than a 7 percent increase in fresh strawberry purchases. Of course, if family size is increased from six to eight, or one-third, the purchase increase is still nearly 6 percent. If purchases are placed on a per-family-member basis, total purchases increase with family size and decrease quite drastically on a per capita basis. In a family of two persons, the per capita purchases amount to 4 pounds of fresh strawberries and 2 pounds of frozen. In a family of six persons, the per capita purchases are only about 1½ pounds of fresh and 1 pound of frozen strawberries.

Housewife Employment

Employment of the housewife outside the home, shown in Fig. 6, results in a moderate increase in family purchases of both fresh and frozen strawberries. The average employed housewife purchased ½ pound more fresh strawberries and ¼ pound more frozen strawberries per year than those who were not employed. This amounts to increases of 6 percent in fresh and 5 percent in frozen strawberry purchases.

Age of the Housewife

Age of the housewife is important in determining family strawberry purchases, as shown in Fig. 7. Purchases of both fresh and

frozen strawberries increase with age up to about 50, with fresh strawberries showing the greatest increase. Purchases of both forms decrease rapidly beyond 55.

Implications of the Findings

Several things have been presented which indicate varying influences on fresh and frozen strawberry purchases. Joint consideration of these influences can be used to indicate probable future changes in strawberry purchases.

Strawberry consumption has increased steadily in the post-World War II period, but has ceased its rapid increase in recent years. M.S.U. Consumer Panel purchases are nearly double the U.S. per capita consumption of frozen strawberries and are significantly greater in fresh ones. This may be because strawberries are more abundant and cheaper to Lansing residents than to the average U.S. consumer.

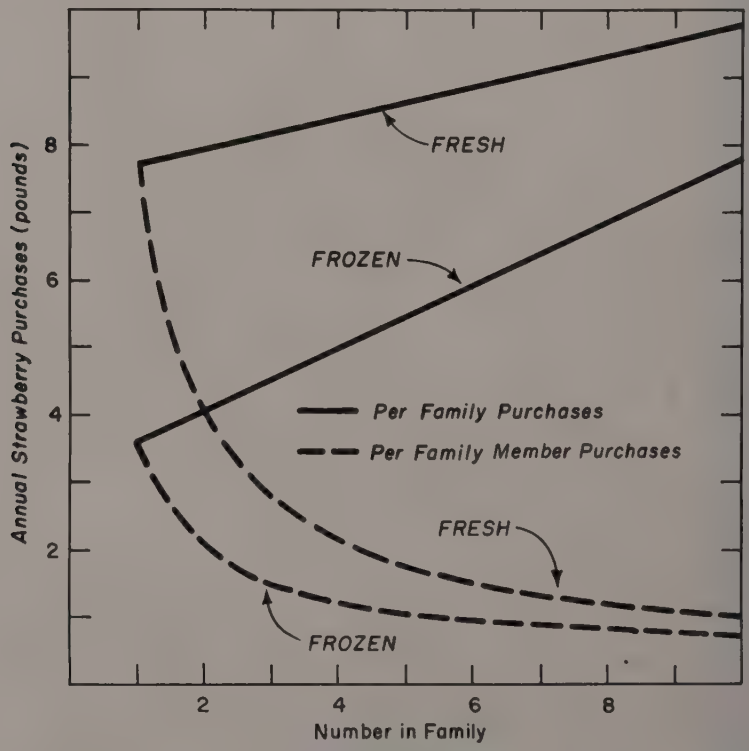

Fig. 5. Annual purchases of fresh and frozen strawberries per family and per family member with respect to family size.

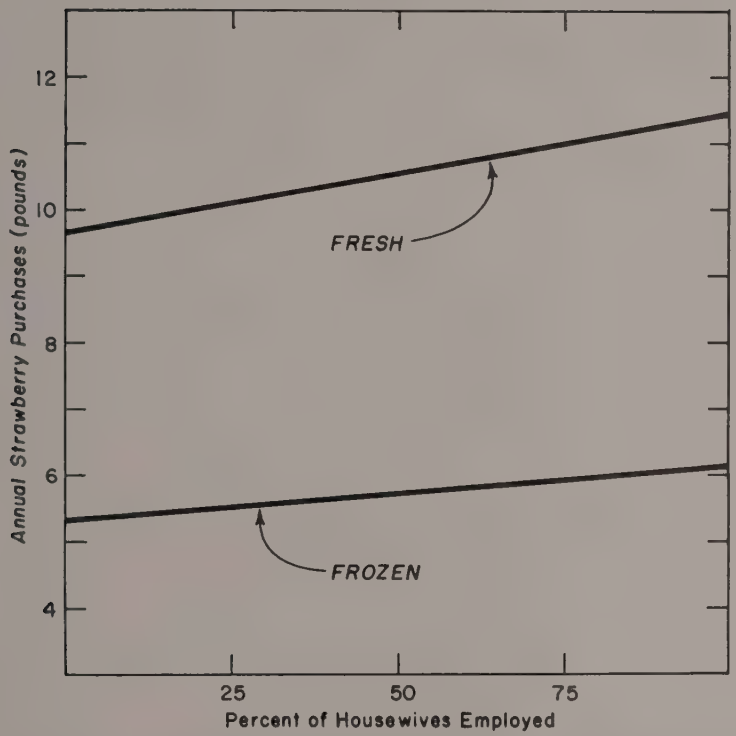

Fig. 6. Relationship between annual strawberry purchases per family and employment of the housewife.

The seasonal pattern of fresh strawberry consumption is revealing with respect to source of berries. Nearly all of the fresh strawberries were purchased during Michigan's harvesting season, indicating that a very small part of the total fresh strawberries are shipped into the area. While fresh strawberries can be shipped into any area during the year, it is apparent that this is a very minor source of fresh strawberries in Lansing. Imported fresh berries evidently are faced with disadvantages — presumably costs — which limit consumption in comparison with a plentiful, although seasonal, supply of local berries. Michigan producers, therefore, are the primary source of fresh strawberries in Lansing. There is no reason to believe that this will not continue.

Seasonality of frozen strawberry purchases is somewhat surprising, but is probably due to a large extent to seasonal competition from other berries and fresh fruits, including fresh strawberries. Purchases

are below average from the beginning of the Michigan fresh strawberry harvest and remain low until near the end of January, when a rapid increase is experienced. This rapid increase is difficult to explain, but is interesting because similar seasonal increases have been attributed to advertising and promotional campaigns for other products.

A small percentage of the families in the panel purchased a comparatively large percentage of the strawberries. While some undoubtedly do not like strawberries, it seems unlikely that 20 percent of the families do not like fresh strawberries and 37 percent do not like frozen strawberries.[4] In fact, a survey of M.S.U. Consumer Panel members conducted by Shaffer[5] revealed that only 1 percent of the families did not expect to purchase either fresh or frozen strawberries because someone in the family did not like them. The reasons given

[4]These are the percentages of families who purchase no strawberries of the given category during a given year.

[5]Shaffer, James Duncan (1959). Consumers' attitudes toward 157 food items. Quart. Bul., Mich. Agr. Expt. Sta., Mich. State Univ. 42:98.

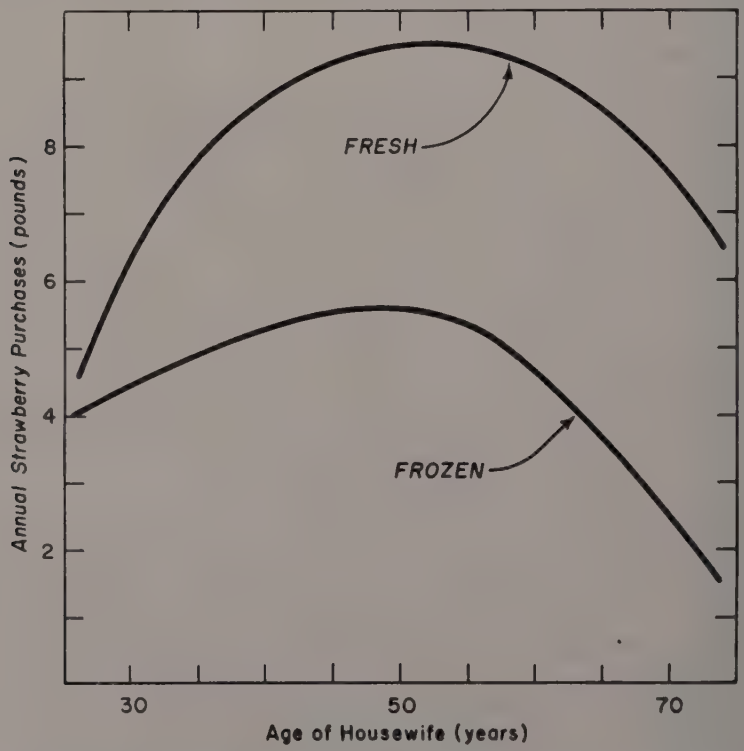

Fig. 7. Relation between annual strawberry purchases per family and age of the housewife.

most often for not purchasing were that strawberries were grown in their own garden or those in the markets were too high priced. Shaffer also found that only 10 percent of the panel members did not expect to purchase fresh strawberries and 17 percent did not expect to purchase frozen strawberries. Comparison with the actual purchase record, given in Panel A of Fig. 3, indicates that many people who expect to buy strawberries do not actually buy them.

The large number of families who do not purchase strawberries, therefore, would appear to be a fruitful area for attempts to increase strawberry consumption. Perhaps even better results, though, could be obtained among the many families who purchase strawberries at least once during a year, but purchase a very small quantity.

Families with larger incomes purchase more strawberries than families with smaller incomes. Fresh strawberry purchases increase rapidly with income in the lower income range, but reach a maximum at about $6,000. Frozen strawberry purchases increase less rapidly with income, but continue to increase over a large income range and, in fact, seem to increase more in the high than in the low income range. The relationship existing between purchases and income in a given time period will not necessarily exist between time periods. If today's low income families somehow acquire higher incomes next year, it does not necessarily mean that they will purchase more strawberries. Nevertheless, it does indicate the effect of income on strawberry purchases and gives reason to believe that the trend toward higher incomes in the U.S. has a favorable influence on demand for strawberries.

Strawberry purchases are greater in large than in small families. With present trends toward larger families, this is an influence which should increase strawberry consumption. However, purchases increased much less proportionally with family size, so this actually is an influence which decreases *per capita* strawberry consumption.

Employment of the housewife outside the home results in a greater average family strawberry purchase. With our present trend of increasing housewife employment, this becomes a favorable, although small, influence on strawberry demand.

Housewife age has some influence on strawberry purchases. Up to about 50 years of age, average annual purchases of both fresh and frozen strawberries increased. This may indicate that as housewives grow older they purchase more strawberries. It may also indicate that our presently middle-aged housewives for some reason have developed

a liking for strawberries in past years. U.S. per capita strawberry consumption was at a peak when these ladies were in their early twenties — and have retained that liking. Young housewives of today have not developed a taste for strawberries. Many of the latter group grew up when strawberry production was at a low — the World War II years — and have been faced with many products that compete with strawberries for purchases. The drastic decrease in strawberry purchases at ages over 50 is difficult to explain. Two possibilities seem logical. Elderly people in general decrease food consumption and the elderly housewife is usually buying for a smaller family.

Conclusion

From 1946 to 1955, frozen strawberry per capita consumption increased and fresh strawberry per capita consumption decreased steadily. Since 1955, fresh strawberry consumption has increased more rapidly than has frozen. Future purchases of fresh and frozen strawberries will, to a large extent, be a result of developments in the family characteristics described in the foregoing sections. Present trends in family income, housewife employment and family size suggest a continuing increase in total strawberry consumption. The association of family purchases and housewife age is probably an influence for decreasing future strawberry purchases. On the balance, it appears likely that purchases of both fresh and frozen strawberries will continue to increase.

DEVELOPING AND MARKETING DAIRY PRODUCT FOODS

1. Frozen Whipped Cream

By DORIS DOWNS, BEVERLY WILKINSON and T. I. HEDRICK[1]

INSTITUTION ADMINISTRATION AND DAIRY DEPARTMENTS

THE DRASTIC DECLINE in consumption of whipping cream in American homes since the pre-World War II period concerns the dairy industry. Various reasons may account for the decline. Consumers who demand convenient, ready-to-serve foods may substitute aerated or powdered toppings for whipping cream. Calorie-conscious and/or economy-minded persons, who might enjoy an occasional serving of whipped cream, cannot always use a half-pint of whipping cream.

Frozen whipped cream presents possibilities for marketing an old-fashioned treat in a modern form which might satisfy consumer demands and encourage sales. The homemaker can remove the desired amount of frozen whipped cream and return the remaining portion to the freezing unit. The whipping chore and the problem of utilizing excess whipping cream are thus eliminated. Convenience, portion control, and the advantage of an on-hand supply of ready-to-use whipped cream might encourage the homemaker to use more of it than she would if she had to buy and use at least a half-pint carton.

This study was undertaken to investigate the processing, packaging, storage, palatability and consumer acceptance of cream which was flavored, whipped and frozen. The ultimate goal was to process and handle the frozen whipped cream with common dairy equipment and facilities to eliminate the expense of specially designed equipment. No reports on the development and use of frozen whipped cream were found in reviewing literature.

[1]The authors express sincere appreciation to Helen Brown, Evelyn Wheeler and Victor Armitage for their assistance in conducting the trials.

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METHOD

During the preliminary trials, the formula, stabilizers, equipment and procedures were determined for subsequent trials. Variables of handling and storing the product were then introduced. Frozen whipped cream for merchandising in the Michigan State University Dairy Store and selected dairy establishments was prepared with standard dairy plant equipment as the last phase of the project.

The basic ingredients and formula for the project were determined and six variations were created by the incorporation of selected stabilizers:

35% butterfat cream
Granulated sugar — 10% weight of cream
Vanilla —.31% weight of cream
Stabilizer — one of the following:

1. Control — no stabilizer.
2. Granulated pure gelatin — .05% weight of cream.
3. Carrageenan[2] #1 — .05% weight of cream.
4. Carrageenan #2 — .05% weight of cream.
5. High temperature process nonfat dry milk — 2% weight of cream.
6. Low temperature process nonfat dry milk — 2% weight of cream.

In each phase, whipping cream was pasteurized in one lot in a trunnion kettle. Enough cold cream was removed to dissolve stabilizers. The cream was slowly agitated while heating to 148° F. and was maintained at this temperature for 30 minutes. Three of the stabilizers required special preparation before they could be incorporated in the pasteurized cream. Gelatin was hydrolized in cold cream. Carrageenan #1 and carrageenan #2 were each added to cold cream and heated in double boilers to 175° F. and stirred until completely dissolved. One prepared stabilizer was added to each of the 6 batches of cream and stirred until well blended. The nonfat dry milk was added directly to the pasteurized cream. The pasteurized cream was cooled to 40° F. and refrigerated overnight.

The cream was whipped and packaged on the day after it was

[2]Carrageenan is the name recommended by a subcommittee of the ACS in 1957 for the dehydrated edible gelose extract of the natural seaweed Irish Moss. Carrageenan is also known as Irish Moss, pearl moss, rocksalt moss, carrageen moss, carrageen, carragheen, carrageenin, and by a number of other names.

pasteurized. Each batch of cream was placed in a chilled bowl, sugar and vanilla were added, and it was beaten at high speed until it was of desirable consistency. Little difference in whipping time, color or stiffness was noted among the different samples of cream. Three one-fourth cup samples of whipped cream were weighed to determine the specific gravity for each variable. Average specific gravities were:

Stabilizer	Specific gravity
Control	.655
Gelatin	.657
Carrageenan #1	.639
Carrageenan #2	.673
High temp. NFDM	.630
Low temp. NFDM	.651

Polyethylene bags were selected for packaging. These were filled with approximately 1 cup of whipped cream by means of a gravity flow dispenser. The air was extruded manually from the top of the bags and the bags were closed by rolling down the top wired edge and folding the wire to center of bag. The bags of whipped cream were frozen at −20° F. and stored until needed for testing.

On the day after the cream was whipped and frozen, two samples of each batch were distributed as follows for storage tests:

1. Placed in home refrigerator unit for 10-day storage.
2. Completely thawed at room temperature and refrozen in laboratory freezer. (This variable was included in one phase only).
3. Partially thawed at room temperature and refrozen in laboratory freezer.
4. Completely thawed in the refrigerator and refrozen in laboratory freezer.
5. Partially thawed in refrigerator and refrozen in laboratory freezer.
6. Left in the −20° F. freezer until time for testing.
7. Stored in open-type meat freezer for four days (one phase only).

A small portion of each sample of the 36 variations of whipped cream was served to six judges at one-month intervals. They were evaluated for appearance, color, body, texture and flavor on a 7-point scale.

One bag of each variable was thawed each month and used to determine the amount of drainage. An opening, 1 by 2 inches, was cut and removed from the center of one side of the bag. Each bag was placed with the open side down on a wire screen through which liquid drained into a plastic container. Percentages of drainage were computed by dividing the weights of drippings after 15- and 30-minute intervals by the initial weights.

Frozen whipped cream for consumer trials on a commercial basis was processed in the dairy plant. Proportions of ingredients were the same as in previous trials. Sugar and stabilizer were incorporated into the cream before it was pasteurized in a large vat. The pasteurized mixture was chilled overnight. Vanilla was added just before the product was whipped to 95-100 percent overrun with a Cherry-Burrell continuous freezer. A small amount of ammonia in the machine was required during whipping to cool the product to the correct temperature. No visual evidence of freezing existed although the whipped cream was 28° F. when extruded. The whipped cream was packaged in specially printed polyethylene bags and frozen as in previous trials. Packages of frozen whipped cream were transferred to ice cream holding cabinets in various stores for sales trials.

RESULTS AND DISCUSSION

Data from drainage tests and taste panel evaluations of frozen whipped cream were analyzed statistically to determine the significant differences in the effectiveness of the various stabilizers on the keeping quality of the product after one, two and three months of storage. The limited number of replications of each storage variable did not warrant statistical analysis of the data at this stage of the study. Consumer sales and comments were considered important results of the study.

The appearance, color, body and texture, and flavor of each sample of frozen whipped cream were evaluated subjectively each month. Analysis of variance tests revealed no significant differences in the taste panel evaluations of frozen whipped cream stored for either one or two months. After three months of storage, however, significant differences, due to the type of stabilizer used in the whipped cream, were found in the scores for appearance and body and texture (Table 1).

The appearance of frozen whipped cream containing no stabilizer or carrageenan #1 received significantly lower scores at the 1 percent

level than whipped cream stabilized with either carrageenan #2 or low temperature process nonfat dry milk. The scores were lower at the 5 percent level of significance than those for whipped cream which contained gelatin or high temperature process dry milk (Table 1.) The appearance of frozen whipped cream stabilized with carrageenan #2 and low temperature nonfat dry milk was also significantly preferred at the 1 and 5 percent levels, respectively, over that containing gelatin.

TABLE 1—Average scores(a) for appearance, body and texture after three months of storage

Variable	Appearance	Body and texture
Control	4.83	4.91
Gelatin	4.90	4.94
Carrageenan #1	4.82	4.85
Carrageenan #2	5.25	5.38
High temperature NFDM	4.99	4.90
Low temperature NFDM	5.22	5.31

(a) Scores based on scale of 1 to 7 with 7 denoting excellence.

After three months of storage, the body and texture of frozen whipped cream containing carrageenan #2 or low temperature process nonfat dry milk was significantly superior to whipped cream stabilized with the other four products (Table 1). Highly significant differences were found between the scores for samples of whipped cream which contained carrageenan #2 and all other samples except those with low temperature process nonfat dry milk. Whipped cream containing low temperature process nonfat dry milk was significantly preferred at the 1 percent level over that stabilized with carrageenan #1, and at the 5 percent level, over whipped cream containing no stabilizer, gelatin or high temperature process nonfat dry milk.

The average taste panel scores were generally favorable, although data from individual storage variables were insufficient for statistical analysis. During the first two months, the average scores were in the "good" range for each storage variable and were within one-half of a point of each other. Average scores for storage variables were mostly in the high "fair" range after three months and varied less than one point.

No significant differences were found among figures for the drainage from the six variables of frozen whipped cream until the three-

month storage period was reached, then only after the products were allowed to drain for 30 minutes (Table 2). The whipped cream stabilized with either type of nonfat dry milk allowed significant amount of drainage at the 5 percent level. Frozen whipped cream containing either of the nonfat dry milks produced significantly more drainage than that stabilized with carrageenan #2. Unstabilized whipped cream drained less than whipped cream which contained low temperature process nonfat dry milk.

TABLE 2—Average percentages of drainage from frozen whipped cream after three months of storage

Variable	Drainage time	
	15 minutes	30 minutes
Control	.0152	.0271
Gelatin	.0161	.0294
Carrageenan #1	.0115	.0190
Carrageenan #2	.0047	.0094
High temperature NFDM	.0159	.0284
Low temperature NFDM	.0195	.0343

Sales of frozen whipped cream in the Michigan State University Dairy Store have been very good. Although only one-size container was offered (4 oz., a cup in volume) sales of frozen and liquid whipping cream, based on the same period the previous year for one-half pint liquid whipping cream sales, increased 145 percent in November, 159 percent in December and 266 percent in January.

A local independent dairy store reported good demand during the initial two-month trial. In fact, customers expressed keen disappointment when the product was temporarily out of stock. Consequently, a policy to maintain a ready supply has been established. Consumers have been complimentary about frozen whipped cream. No complaints were received in written or verbal form.

SUMMARY AND CONCLUSIONS

Whipping cream was processed successfully into frozen whipped cream and maintained excellent quality for two months. After three months of storage, the frozen whipped cream stabilized with carrageenan #2 was outstandingly good in appearance, body, texture,

drainage, flavor and color. However, statistical analysis of the data from taste panels and drainage tests indicated that three months of storage resulted in decreased quality of the body and texture of some of the products. Limited observations of frozen whipped cream stored under various conditions were generally favorable.

Consumers showed a strong interest in a frozen whipped cream product which offered them a high quality supply of convenient ready-to-use whipped cream.

QUALITY DETERIORATION OF FORCED RHUBARB DURING HANDLING AND MARKETING[1]

By J. A. COOK

Department of Horticulture

RHUBARB IS AN IMPORTANT forced vegetable in Macomb County in Southeastern Michigan where about 5 million pounds are produced annually. The high value of this crop, together with its perishability, makes it imperative that forced rhubarb be handled carefully and properly during marketing operations.

The fungicidal spray programs recommended by Murakishi, et al.,[2] have improved the quality of forced rhubarb at harvest when leaf rot has been a problem. Further improvement in post-harvest quality and its retention is needed if rhubarb is to continue to be a profitable crop. Increasing production of forced rhubarb in Michigan and competing areas will make high quality an even more important factor for successful marketing.

Factors affecting quality of forced rhubarb after harvest were studied and evaluated on the basis of leaf breakdown and loss of crispness during the marketing period.

GENERAL PROCEDURES

Freshly harvested rhubarb leaves[3], obtained from commercial growers in Macomb County, were brought to East Lansing for these tests. Rhubarb obtained in bulk was packed at the laboratory into the small (5-pound capacity) paperboard cartons used commercially, or into the large (15-pound capacity) corrugated cartons recently in-

[1]Rhubarb for this study was provided by the Michigan Hothouse Rhubarb Growers Association. H. S. Potter, Department of Botany and Plant Pathology, assisted in setting up and evaluating the treatments.

[2]Murakishi, Harry H., Howard S. Potter, and W. Lane Rushmore (1957). The cause and control of post-harvest leaf breakdown of hothouse rhubarb. Mich. Agr. Expt. Sta. Quart. Bul. 40(1):147-153.

[3]Botanically, a leaf consists of a flat expanded segment, the leaf blade, and its stem, the petiole. The botanical definition will apply in this report and specific treatment of the leaf blade or petiole will be indicated.

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troduced. In several instances, when commercially-packed rhubarb was used, it was repacked in the original container following application of the pre-storage treatments.

Controlled temperature rooms, equipped with refrigeration and forced air circulation, were used to store the sample materials. Relative humidity was maintained at between 70 and 90 percent.

The rhubarb was weighed at the beginning and the end of the storage period. Weight changes are presented as a percent of the original weight. The rhubarb was rated subjectively for quality on a numerical scale at the end of the storage period. Crispness and leaf blade breakdown were separately judged, using a rating scale of from one to nine. A rating of one was given to rhubarb that was extremely wilted or very severely affected by breakdown. A rating of nine indicated very high quality without wilting or breakdown. Intermediate ratings were used.

RESULTS AND DISCUSSION

Table 1 gives results of tests comparing two sizes of commercial cartons and those to determine the effect of ventilation holes in the carton. The ventilation holes were circular openings approximately ¾ of an inch in diameter or slots ⅜ by 4 inches. Two openings were employed in each end of the carton near the position of the leaf blades.

Changes in weight during storage and final ratings for crispness and leaf breakdown were quite similar for rhubarb in the small and large cartons, and also in the non-ventilated and ventilated cartons. The slight differences found indicate that size or ventilation of the carton was a minor effect, suggesting that either the large or small commercial carton, as commonly used without ventilation, is a satisfactory container in these respects.

TABLE 1—Effect of carton size and ventilation holes on rhubarb stored for 6 days at 32-45°; composite of four tests

Treatment	Units treated	Weight change	Ratings	
			Crispness	Breakdown
Small carton	11	−3.8%	5.0	6.2
Large carton	5	−3.2	5.2	6.5
Non-ventilated carton	3	−2.2	5.3	7.0
Ventilated carton	3	−2.6	5.3	7.3

Value of supplying water to rhubarb following harvest was examined by comparing the usual dry storage method with that having petiole bases in 3 to 6 inches of water. The leaves were held upright with the petiole butts in metal containers holding the water. As shown in Table 2, the leaves with their petiole butts in water gained weight during the 6-day test period; whereas, leaves packed in cartons lost weight. Differences at the end of storage in petiole crispness occurred at 32°F., with those having a water supply being considerably better than those in the dry pack. At higher temperatures of 40° and 50°, however, water supply did not effect retention of crispness. Factors such as aging and rate of water transfer through the petioles were apparently more important in affecting crispness than was a source of moisture. Loss or gain of weight, under test conditions, was not a reliable index of quality loss associated with wilting. The relatively high ratings for breakdown show the leaf blades remained in good condition for the duration of the tests.

TABLE 2—Effect of holding petiole bases in water on weight change, crispness and breakdown ratings of rhubarb stored 6 days; one 5-pound carton per treatment

Treatment	Weight change	Ratings	
		Crispness	Breakdown
32° Storage			
Dry stored	−2.2%	5	8
Water stored	+1.8	8	8
40° Storage			
Dry stored	−3.9	3	8
Water stored	+1.3	3	7
50° Storage			
Dry stored	−2.4	5	7
Water stored	+6.3	5	8

Experiments using wax applications and leaf blade removal to restrict loss of moisture from the leaves are reported in Table 3.

The whole leaf, leaf blade, or petiole was dipped in a liquid wax emulsion[4] diluted with water to 50 percent of its original concentration and allowed to drain before packing.

Wax effectively reduced loss of weight when applied to the leaf blade alone and leaf petiole alone, or to both. Waxing leaf blades

[4]W-5709, S. C. Johnson & Sons Company, Racine, Wisconsin.

TABLE 3—Effect of waxing and removal of leaf blades on weight change, breakdown and crispness of stored rhubarb; one 5-pound carton per treatment

Treatment	Weight change	Ratings	
		Crispness	Breakdown
32°—8 days storage			
Check	−5.0%	3	7
Leaf blades cut off	−3.5	6	—
50% wax, leaf blades	−1.1	8	5
50% wax, whole leaf	−2.1	8	5
32°—6 days storage			
Check	−8.2	3	5
50% wax, petiole	−3.4	3	5
50% wax, leaf blades	−3.8	8	3

reduced weight losses more than actual removal of the blades. Crispness ratings corresponded with weight losses with but one exception. That was wax application to the petiole alone which reduced weight loss without any observed effect on retention of crispness.

Wax invariably caused damage to the leaf blades, reflected by the low breakdown ratings for all treatments that included wax application to the leaf blades. Since the damage, except in the early stages, was not easily distinguished from that caused by common leaf rot, both disorders were considered as "breakdown". Early symptoms of wax damage occurred as tan to brown necrotic spots which soon turned darker in color. The spots were most common in folds and creases of leaf blades and were not found on the petioles. The pattern of injury suggested that drops of the wax solution remaining on the leaf surface after dipping caused the injury.

Lower concentrations of wax emulsion were tested for suitability as leaf blade applications. Comparisons of the effects of 25 percent (1 part wax to 3 parts water), 17 per cent (1 to 5), and 8 percent (1 to 11) dilutions are made in Table 4.

These wax applications consistently reduced weight loss. The 25-percent solution caused a large reduction with smaller differences observed in 17- and 8-percent treatments. Appreciable retention of crispness was attained with 25- and 17-percent dip treatments. Dipping the rhubarb in the 8-percent wax solution did not appreciably aid in maintaining crispness. All wax treatments increased breakdown over their comparable checks.

TABLE 4—Effect of various concentrations of emulsified wax solution in water applied to leaf blades of rhubarb before storage for 6 days

Treatment	Units treated	Unit size	Weight change	Ratings	
				Crispness	breakdown
Check	1	5 lb.	−8.2%	3	5
25% wax	1	5	−4.0	7	4
Check	3	5	−3.5	4.7	6.8
	3	15			
17% wax	3	5	−2.0	6.8	5.2
	3	15			
Check	2	15	−6.1	5.5	6.0
17% wax	2	15	−5.4	7.5	3.5
8% wax	2	15	−5.6	6.0	4.0

A reduction in moisture loss by providing a water barrier surrounding the packed and untreated rhubarb was attempted in two other ways. Results obtained with cartons made of wax-impregnated cardboard are presented in Table 5. Marked benefits to the rhubarb were evidenced by the wax cartons over regular cartons (check) in respect to reduced weight loss and loss of crispness. Breakdown ratings of the rhubarb in the two kinds of containers were similar. Moisture absorption by the waxed carton was nil; whereas, the untreated cartons were found to increase in weight by as much as 15 percent over their original weight.

TABLE 5—Effect of wax-impregnated cartons on rhubarb stored at 32°F.; two 5-pound cartons per treatment

Treatment	Weight change	Crispness	Breakdown
Check	−6.5%	3	6
Waxed carton	−1.5	6.5	7

The second method of protecting rhubarb against moisture loss to the container and to the atmosphere consisted of placing the leaves into open-end polyethylene film tubes within the cartons. After storing the rhubarb for 6 days at 32°F., it was found polyethylene effectively reduced weight loss and wilting (see Table 6). There were no adverse effects of the film on breakdown of the leaves.

TABLE 6—Effect of polyethylene liners inside cartons; one 5-pound carton per treatment

Treatment	Weight change	Ratings	
		Crispness	Breakdown
Check	−8.2%	3	5
Polyethylene tube	−1.7	7	5

Although weight changes in cartons were not recorded for the test shown in Table 6, results of another experiment showed that the primary effect of the film barrier between the rhubarb and the carton was to prevent moisture absorption by the carton. In this test, the packed carton was completely "overwrapped" with polyethylene film and the rhubarb lost 4.2 percent of its weight, while rhubarb in unwrapped cartons lost 5.0 percent.

The value of captan as a fungicidal spray material for controlling leaf rot during the growing season[5] suggested its possible use for controlling post-harvest development of this disease. A residue (100 p.p.m.) is acceptable on rhubarb according to the Food and Drug Administration. Captan was applied by dipping the freshly harvested rhubarb in a solution containing 2 pounds of captan per 100 gallons of water. The rhubarb was then stored at 40° or 55° F. for 6 days prior to quality rating. Results, given in Table 7, show captan reduced breakdown at 55°, but not at 40° F. The quality of treated leaf blades held at 55° F., however, was not quite as good as those held at 40° F. Since rhubarb often is subjected to temperatures of 55° F. and higher

[5]Murakishi, Harry H., *et al.*, *op. cit.*

TABLE 7—Effect of a captan dip on rhubarb stored 6 days; one 15-pound carton per treatment

Treatment	Ratings	
	Crispness	Breakdown
40° Storage		
Check	5	7
Captan	6.5	7
55° Storage		
Check	4	4
Captan	5	6

during marketing, it is likely that a post-harvest application of captan would prove useful for reducing deterioration losses due to leaf rot.

The tests described above, in which several storage temperatures were employed, point out benefits of low temperature for quality retention. Temperature effects upon weight loss, crispness and breakdown ratings are shown in Table 8. Temperature comparisons within each of the three groups of tests show that the overall quality was best maintained at lowest temperatures. Although comparisons between tests are not valid, because of the interaction of other factors, it is quite evident that a temperature of 32° F. is more favorable for quality retention than 40° F.

TABLE 8—Effect of temperature on stored rhubarb; composites of wax temperature, and captan treatments

Treatment	Units treated	Size	Weight change	Ratings	
				Crispness	Breakdown
Wax test					
32°	4	5 lb.	−0.2%	6.0	7.8
40°	4	5	−2.1	5.0	6.8
50°	4	5	+0.1	6.5	6.2
Temperature test					
38°	6	5	−3.8	4.3	6.7
	2	15			
45°	3	5	−5.0	4.4	4.4
	1	15			
Wax and captan test					
40°	7	15	−2.1	6.2	5.7
55°	7	15	−4.3	5.4	3.9

SUMMARY AND CONCLUSIONS

Factors affecting quality deterioration of forced rhubarb following harvest were studied. Moisture losses, retention of crispness and development of breakdown of the leaf blades were used in quality comparisons after holding the rhubarb for 6 to 8 days at various temperatures. Of factors studied, application of low temperatures proved most beneficial in retaining quality, and a temperature of 32° F. was better than 40° and higher. Carton size and ventilation had no effect. Reduced moisture losses were obtained by applying wax to the leaves and protecting the packed rhubarb from water uptake by the carton. Waxes proved unsatisfactory because of injury to leaves. Cartons

made of wax-impregnated paper and placement of a moisture barrier of polyethylene around the rhubarb within the carton aided crispness retention without damage to the crop. Captan applied to leaf blades by post-harvest dips reduced losses due to leaf rot at holding temperatures of 55°, but not at 40° F.

It is recommended that forced rhubarb be held under refrigeration following harvest and protected against excessive moisture loss during storage and marketing by packaging in containers constructed of non-absorbent material or lined with moisture-proof film or paper.

DISTRIBUTION OF EXPENDITURES FOR VARIOUS FOODS, 1955-57, M.S.U. CONSUMER PANEL[1]

By H. F. WANG and G. G. QUACKENBUSH

Department of Agricultural Economics

During the period of operation of the M.S.U. Consumer Panel[2] numerous inquiries were made concerning the distribution of expenditures for food. Some were interested in major food groups, while others wanted to know about the breakdown of expenditures within a major food group such as dairy or fruit. Still others were interested in only a subgroup of products such as beef or frozen fruits. Finally, there were inquiries about brands of a specific product.

It has often been stated that a modern supermarket has 6,000 to 8,000 items on its shelves. This, of course, includes the various package sizes of a product and the numerous brands of products. The M.S.U. Consumer Panel diary and tabulations do not include this detailed description of most products. There were, however, about 900 different items included, representing all food bought for home use.

The breakdown of expenditures for these 900 items is reported here and probably is one of the most detailed data of this kind available. It should be useful to many firms which produce specialized products, to researchers in selecting products for future studies, to various agricultural trade associations, to food processing industries, and others.

Figure 1 gives a breakdown of expenditures by major food groups. In Table 1 the distribution of expenditures by subgroups of products and individual items is listed. Data are based on expenditures for the three years 1955-57. When data were available for only one or two years, they were treated no differently than if they had been available

[1]M.S.U. Consumer Panel Report No. 55.

[2]The M.S.U. Consumer Panel was operated in Lansing, Michigan from February 1951 to December 1958. An average of about 250 families reported weekly. Each family reported the price, quantity, and expenditure for each product. Family incomes were reported weekly. For a report on methodology see Shaffer, J. D., and G. G. Quackenbush, (Aug. 1955). "Cooperation and sampling in four years of M.S.U. consumer panel operation," *Quart. Bul.*, 38:85-103.

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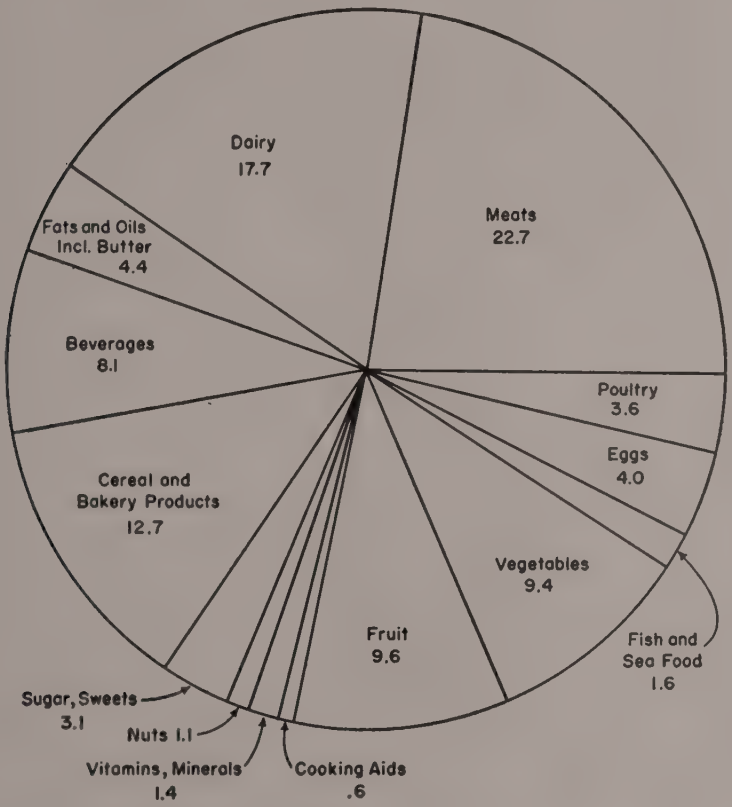

Fig. 1. Distribution of food expenditures among food groups, 1955-57 average, M.S.U. Consumer Panel.

for all three; that is, a total for the three years was computed. Data for few products, mostly new products, were affected by this procedure. A total of 42,762 weekly food purchase diaries is included in the tabulations.

TABLE 1—Total expenditure, average weekly expenditure per family and distribution of expenditures among food items, 1955-57, M.S.U. consumer panel

Item	1955-57 total expenditure for all families in the panel	Average expenditure per family weekly	Percent of total expenditure for food at home	Percent of subgroup expenditure for food at home
	(dollars)	(dollars)	(percent)	(percent)
ALL FOODS	**707,432.25**	**16.520**	**100.00**	—
Fresh milk	**85,607.43**	**2.000**	**12.10**	**100.00**
Homogenized—Vit. D	44,015.94	1.029	6.23	51.42
Multiple vitamin	8,896.36	.208	1.26	10.39
Homogenized—plain	12,479.50	.292	1.77	14.58
Regular pasteurized	10,780.63	.252	1.53	12.59
Jersey or Guernsey	1,259.88	.029	.18	1.47
Buttermilk	658.67	.015	.09	.77
Chocolate	1,127.47	.026	.16	1.32
Skim milk, plain	3,830.98	.090	.54	4.48
Skim milk, vitamins	649.24	.015	.09	.76
Sour milk, yoghurt	13.41	—	—	.02
Egg nog, etc	191.02	.004	.02	.22
Other milk	12.17	—	—	.01
Half and half	1,692.16	.040	.24	1.98
Canned dairy products	**2,669.69**	**.062**	**.38**	**100.00**
Evaporated—unsweetened	2,103.76	.049	.30	78.80
Condensed—sweetened	43.88	.001	.01	1.64
Canned skim	81.16	.002	.01	3.04
Canned—baby formulas	440.89	.010	.06	16.51
Dried dairy products	**1,264.41**	**.028**	**.18**	**100.00**
Powdered—skim milk	872.10	.020	.12	68.97
Cool shake	15.67	—	—	1.24
Powdered—whole milk	20.70	—	—	1.64
Malted milk powder	67.21	.002	.01	5.32
Chocolate, carnation	42.92	.001	.01	3.39
Powdered—baby formulas	136.16	.003	.02	10.77
Ice cream mix	10.08	—	—	.80
Sherbet mix	9.80	—	—	.78
Pream—powdered cream	89.77	.002	.01	7.10
Cream	**4,114.91**	**.097**	**.58**	**100.00**
Coffee cream	2,557.37	.060	.36	62.15
Whipping cream	1,296.67	.030	.18	31.51
Whip (Reddi-Whipp, etc.)	108.07	.003	.02	2.63
Sour cream	152.80	.004	.02	3.71

TABLE 1—Continued

Item	1955-57 total expenditure for all families in the panel	Average expenditure per family weekly	Percent of total expenditure for food at home	Percent of subgroup expenditure for food at home
	(dollars)	(dollars)	(percent)	(percent)
Ice Cream	**14,187.64**	**.331**	**2.01**	**100.00**
Hand packed	1,298.85	.030	.18	9.15
Pre-packaged ice cream	11,341.49	.265	1.60	79.94
Other ice cream	583.34	.014	.08	4.11
Sherbets and ices	690.68	.016	.10	4.87
Dairy Queens, Frosties	273.28	.006	.04	1.93
Cheese	**17,233.28**	**.404**	**2.44**	**100.00**
Natural American	4,919.74	.115	.70	28.55
Processed American	2,487.94	.058	.35	14.44
Cheese spread	885.43	.021	.13	5.14
Swiss	500.19	.012	.07	2.90
Other cheese	1,549.19	.036	.22	8.99
Cream cheese	624.24	.015	.09	3.62
Cottage cheese	6,266.55	.147	.89	36.36
Fats and Oils	**30,940.14**	**.728**	**4.37**	**100.00**
Butter	14,840.36	.347	2.10	47.96
Whipped butter	2.44	—	—	.01
Oleomargarine	6,292.65	.147	.89	20.34
Whipped margarine	.23	—	—	—
Lard	498.53	.012	.07	1.61
Swiftning	592.35	.014	.08	1.91
Vegetable shortening	3,208.66	.075	.45	10.37
Other fats	101.62	.002	.01	.33
Cooking oils	794.27	.019	.11	2.57
Mayonnaise	764.87	.018	.11	2.47
Salad dressing	2,202.36	.052	.31	7.12
Roquefort dressing	90.28	.002	.01	.29
Salad oils, etc	346.74	.008	.05	1.12
French dressing	664.94	.016	.09	2.15
Other oils	170.92	.004	.02	.55
Sandwich spreads, tartar sauce	222.33	.009	.03	.72
Whips (name kind)	124.70	.003	.02	.40
Homemade dressing	8.83	—	—	.03
Diet dressing	13.06	—	—	.04
Beef	**75,497.46**	**1.765**	**10.67**	**100.00**
Beef carcasses, etc	3,664.34	.086	.52	4.85
Canned beef	521.19	.012	.07	.69
Corned beef	966.37	.023	.14	1.28
Chipped beef	940.69	.022	.13	1.25
Hamburger	18,396.04	.430	2.60	24.37
Ground steak	4,139.63	.097	.59	5.48

Continued on next page

TABLE 1—Continued

Item	1955-57 total expenditure for all families in the panel	Average expenditure per family weekly	Percent of total expenditure for food at home	Percent of subgroup expenditure for food at home
	(dollars)	(dollars)	(percent)	(percent)
Beef liver	802.04	.019	.12	1.06
Heart, tongue, etc.	249.26	.006	.04	.33
Liver (baby food)	7.74	—	—	.01
Beef (baby food)	256.18	.006	.04	.34
Rib roast (bone removed)	882.72	.021	.12	1.17
Rib roast (bone in)	1,767.48	.041	.25	2.34
Other roast (bone removed)	3,072.19	.072	.43	4.07
Other roast (bone in)	2,881.83	.067	.41	3.82
Chuck roast	10,108.73	.236	1.43	13.39
Round and swiss steak	7,667.27	.179	1.08	10.16
Sirloin steak	6,499.56	.152	.92	8.61
Porterhouse and T-bone steak	4,277.86	.100	.60	5.67
Other steak	5,205.42	.122	.74	6.89
Stewing beef	1,372.81	.032	.19	1.82
Boiling beef and short ribs	1,038.12	.024	.15	1.38
All other beef	779.99	.018	.11	1.03
Lamb—Mutton	**1,537.27**	**.035**	**.22**	**100.00**
Carcasses, etc.	16.40	—	—	1.07
Chops—steaks	541.10	.013	.08	35.20
Lamb (baby food)	62.35	.001	.01	4.06
Roasts (leg, etc.)	609.93	.014	.09	39.68
Other lamb—mutton	307.49	.007	.04	20.00
Pork	**52,371.04**	**1.225**	**7.40**	**100.00**
Carcasses, etc.	559.08	.013	.08	1.07
Bacon	9,747.81	.228	1.38	18.61
Canadian bacon	1,096.62	.026	.16	2.09
Canned pork	119.10	.003	.02	.23
Chops	8,990.48	.210	1.27	17.17
Steaks	1,880.95	.044	.27	3.59
Ham—center slice	2,290.85	.054	.32	4.37
Ham—whole or half (bone removed)	1,617.03	.038	.23	3.09
Ham—whole or half (bone in)	5,120.91	.120	.72	9.78
Ham—canned	1,771.26	.041	.25	3.38
Other ham (bone removed)	1,880.37	.044	.27	3.59
Other ham (bone in)	1,356.23	.032	.19	2.59
Picnic ham, cured butts	2,757.32	.064	.39	5.26
Pork liver	286.58	.007	.04	.55
Heart, tongue, etc.	130.68	.003	.02	.25
Pork (baby food)	10.09	—	—	.02
Roast—fresh	5,550.01	.130	.78	10.60
Sausage—link	1,735.72	.041	.25	3.31
Sausage	2,276.83	.053	.32	4.35

TABLE 1—Continued

Item	1955-57 total expenditure for all families in the panel	Average expenditure per family weekly	Percent of total expenditure for food at home	Percent of subgroup expenditure for food at home
	(dollars)	(dollars)	(percent)	(percent)
Spareribs	1,684.35	.039	.24	3.22
Other pork	887.96	.021	.13	1.70
Side or salt pork	530.43	.012	.07	1.01
Ham loaf mix	90.38	.002	.01	.17
Veal	**3,529.89**	**.083**	**.50**	**100.00**
Cutlets, chops, steaks	1,906.25	.045	.27	54.00
Ground veal	107.48	.003	.02	3.04
Calf liver	134.19	.003	.02	3.80
City chicken	297.08	.007	.04	8.42
Veal (baby food)	18.64	—	—	.53
Roast—bone removed	426.70	.010	.06	12.09
Roast—bone in	428.88	.010	.06	12.15
Stewing—soup veal	53.21	.001	.01	1.51
Other veal	157.46	.004	.02	4.46
Other meats and mixtures	**28,682.43**	**.670**	**4.05**	**100.00**
Unclassified	19.31	—	—	.07
Wieners and franks, etc	7,664.94	.179	1.08	26.72
Bologna—ring or large round	5,319.36	.124	.75	18.55
Other cold cuts	6,719.58	.159	.96	23.68
Prem, Spam, Treet	917.41	.021	.13	3.20
Vienna sausage	99.38	.002	.01	.35
Rabbit, domestic	125.09	.003	.02	.44
Venison—other game	6.44	—	—	.02
Chop suey meat and kabobs	463.58	.011	.07	1.62
Other mixtures	190.03	.004	.02	.66
Mixed meats (baby food)	20.45	—	—	.07
Other meats (baby food)	106.85	.002	.01	.37
Beef and pork	118.31	.003	.02	.41
Veal and pork	36.83	.001	.01	.13
Ham, pork and veal	48.58	.001	.01	.17
Potted meat	123.34	.003	.02	.43
Vegetable and beef (baby food)	168.38	.004	.02	.59
Vegetable and chicken (baby food)	1.12	—	—	—
Vegetable and bacon (baby food)	102.49	.002	.01	.36
Vegetable and liver (baby food)	39.12	.001	.01	.14
Vegetable and lamb (baby food)	54.45	.001	.01	.19
Other mixtures (baby food)	117.72	.003	.02	.41
Meat spreads	292.62	.007	.04	1.02
Vegetable and meat soup	1,612.76	.038	.23	5.62
Pizza pie mix	1,163.81	.027	.16	4.06
Pizza pie—prepared or frozen	337.37	.008	.05	1.18
Lamb pie	.78	—	—	—

Continued on next page

TABLE 1—Continued

Item	1955-57 total expenditure for all families in the panel	Average expenditure per family weekly	Percent of total expenditure for food at home	Percent of subgroup expenditure for food at home
	(dollars)	(dollars)	(percent)	(percent)
Veal pie	1.17	—	—	—
Pork pie	10.55	—	—	.04
Spaghetti sauce and meat	29.70	.001	.01	.10
Chili con carne	381.29	.009	.05	1.33
Hash	428.66	.010	.06	1.49
Mincemeat	177.62	.004	.02	.62
Beef stew	385.98	.009	.05	1.35
Meat balls and spaghetti	249.77	.006	.04	.87
Bouillon cubes	68.31	.002	.01	.24
Beef pie	622.58	.015	.09	2.17
Ravioli and tamales	155.43	.004	.02	.54
Chop suey, chow mein with meat	229.27	.005	.03	.80
Poultry, Chicken	**25,711.30**	**.601**	**3.63**	**100.00**
Chicken	20.01	—	—	.08
Cornish hen	1,251.02	.029	.18	4.87
Broilers and fryers	11,450.09	.268	1.62	44.53
Roasters	1,795.98	.042	.25	6.99
Stewing	2,923.02	.068	.41	11.37
Barbecued chicken	100.23	.002	.01	.39
Chicken (baby food)	53.17	.001	.01	.21
Turkey	4,314.40	.101	.61	16.78
Turkey pie	424.08	.010	.06	1.65
Duck	231.16	.005	.03	.90
Other poultry	35.65	.001	.01	.14
Game birds	13.06	—	—	.05
Vegetable and chicken (baby food)	119.97	.003	.02	.47
Mixtures—chiefly chicken	2.19	—	—	—
Chicken noodle dinner	30.69	.001	—	.12
Chicken a la king	23.27	.001	—	.09
Chicken soup	1,876.96	.044	.27	7.30
Chicken chop suey	41.11	.001	.01	.16
Chicken pie	924.39	.022	.13	3.60
Other	80.85	.002	.01	.31
Eggs	**28,098.94**	**.652**	**3.97**	**100.00**
Eggs	27,992.45	.650	3.96	99.62
Eggs (baby food)	87.56	.002	.01	.31
Eggs and bacon (baby food)	18.93	—	—	.07
Fish, sea foods	**10,964.93**	**.256**	**1.55**	**100.00**
Unclassified	2.00	—	—	.02
Tuna	3,271.62	.077	.47	29.84
Salmon	2,308.70	.054	.33	21.06

TABLE 1—Continued

Item	1955-57 total expenditure for all families in the panel	Average expenditure per family weekly	Percent of total expenditure for food at home	Percent of subgroup expenditure for food at home
	(dollars)	(dollars)	(percent)	(percent)
Other fish	1,965.44	.046	.28	17.92
Fish sticks	558.63	.013	.08	5.09
Lobster, lobster tails	244.25	.006	.04	2.23
Oysters	519.25	.012	.07	4.74
Oyster stew	103.31	.002	.01	.94
Scallops	216.87	.005	.03	1.98
Shrimp	1,407.33	.033	.20	12.83
Shrimp soup	15.86	—	—	.14
Mixtures—chiefly fish	8.42	—	—	.08
Tuna Pie or casserole	98.98	.002	.01	.90
Sardines in oil	161.40	.004	.02	1.47
Sardines in sauce	71.57	.002	.01	.65
Soups and stews	9.11	—	—	.08
Frog legs	2.19	—	—	.02
Beverages	**57,135.03**	**1.336**	**8.08**	**100.00**
Beer	10,830.24	.253	1.53	18.96
Liquors	5,872.05	.137	.83	10.28
Wine	956.73	.022	.14	1.67
Postum	162.17	.004	.02	.28
Cocoa mix	552.68	.013	.08	.97
Cocoa plain	328.54	.008	.05	.58
Coffee—ground	22,488.25	.526	3.18	39.36
Coffee—instant	6,164.19	.144	.87	10.79
Coffee substitute	17.53	—	—	.03
Coffee bags	150.32	.004	.02	.26
Tea bags	1,568.07	.037	.22	2.74
Loose tea	706.61	.017	.10	1.24
Instant tea	91.14	.002	.01	.16
Soft drinks—bottled	6,092.09	.142	.86	10.66
Liquor mixes	579.86	.014	.08	1.01
Soft drink powder	299.89	.007	.04	.52
Ovaltine	177.63	.004	.03	.31
Other teas	2.94	—	—	—
Bosco	15.37	—	—	.03
Minute brew	.42	—	—	—
Toddy	2.24	—	—	—
Mull soy	71.93	.002	.01	.13
Cereal of Postum	.31	—	—	—
Other	3.83	—	—	.01
Breakfast cereals	**9,085.01**	**.209**	**1.28**	**100.00**
Wheaties	852.97	.020	.12	9.39
Corn flakes	803.03	.019	.12	8.84

Continued on next page

TABLE 1—Continued

Item	1955-57 total expenditure for all families in the panel	Average expenditure per family weekly	Percent of total expenditure for food at home	Percent of subgroup expenditure for food at home
	(dollars)	(dollars)	(percent)	(percent)
Rice Honeys	513.86	.012	.07	5.66
Corn Kix	130.82	.003	.02	1.44
Corn Pops, etc	742.84	.017	.10	8.18
Variety pack	377.59	.009	.05	4.16
Pep	80.90	.002	.01	.89
Sugar Jets	237.14	.006	.04	2.61
Muffetts	85.55	.002	.01	.94
Raisin Bran	218.42	.005	.03	2.40
Cream of Wheat	195.42	.005	.03	2.15
Grape Nuts	166.10	.004	.02	1.83
Hominy grits	149.29	.003	.02	1.64
Ralston	131.98	.003	.02	1.45
Rice Chex	121.54	.003	.02	1.34
Oatmeal	852.77	.020	.12	9.39
All Bran	502.62	.012	.07	5.53
Honey Wheats	640.01	.015	.09	7.04
Cheerios	570.43	.013	.09	6.28
Grape Nut Flakes	255.20	.006	.04	2.81
Corn Fetti	21.11	—	—	.23
Post's wheat cereal	40.79	.001	.01	.45
Puffed Rice	103.46	.002	.01	1.14
Corn Soya	23.85	.001	.01	.26
Puffed Wheat	121.96	.003	.02	1.34
Gerbers' baby food	78.92	.002	.01	.87
Malt-O-Meal	79.66	.002	.01	.88
Cocoa Wheats	64.35	.002	.01	.71
Wheat Germ flakes	12.98	—	—	.14
Snack Pak	57.95	.001	.01	.64
Baby food (to be cooked)	20.61	—	—	.23
Pablum	18.85	—	—	.21
Baby oatmeal	51.84	.001	.01	.57
Robinson's breakfast meal	46.56	.001	.01	.51
Farina	19.19	—	—	.21
Cream of Rice	17.36	—	—	.19
Pettijohn	5.58	—	—	.06
Barley pre-cooked	12.83	—	—	.14
Rice pre-cooked	17.91	—	—	.20
Soya	.49	—	—	.01
Trix	187.04	.004	.02	2.06
Special K	445.63	.010	.06	4.91
Surprise	7.51	—	—	.08
Bread	31,621.97	.740	4.47	100.00
White enriched	19,126.95	.447	2.70	60.49

TABLE 1—Continued

Item	1955-57 total expenditure for all families in the panel	Average expenditure per family weekly	Percent of total expenditure for food at home	Percent of subgroup expenditure for food at home
	(dollars)	(dollars)	(percent)	(percent)
White non-enriched	386.92	.009	.05	1.22
Potato—salt rising	402.25	.009	.06	1.27
Whole or cracked wheat	4,586.30	.107	.65	14.50
Rye	1,005.06	.024	.14	3.18
Raisin	610.96	.014	.09	1.93
Cinnamon	579.97	.014	.08	1.83
Vienna, French	435.58	.010	.06	1.38
Boston brown	72.03	.002	.01	.23
Date nut	156.66	.004	.02	.50
Bran	111.89	.003	.02	.35
Diet bread	2,910.00	.068	.41	9.20
Pumpernickel	222.49	.005	.03	.70
Zwieback	24.23	.001	—	.08
Rusk	36.51	.001	.01	.12
Toast	49.15	.001	.01	.16
Half and half	485.75	.011	.07	1.54
Bread crumbs	25.01	.001	—	.08
Other bread	394.26	.009	.06	1.25
Rolls and cakes	**18,278.57**	**.424**	**2.58**	**100.00**
Biscuits—oven ready	224.94	.005	.03	1.23
Biscuits—refrig	351.57	.008	.05	1.92
Other biscuits	23.18	.001	—	.13
Hamburg buns	1,988.52	.047	.28	10.88
Wiener buns	885.36	.021	.13	4.84
Other buns	30.17	.001	—	.17
Raisin breakfast rolls	76.16	.002	.01	.42
Cinnamon rolls	1,134.89	.027	.16	6.21
Nut covered rolls	566.71	.013	.08	3.10
Butterscotch rolls	148.81	.003	.02	.81
Plain frosted rolls	453.93	.011	.06	2.48
Other breakfast rolls	491.56	.011	.07	2.69
Parkerhouse rolls	312.14	.007	.04	1.71
Poppy seed rolls	91.85	.002	.01	.50
Brown and serve rolls	850.86	.020	.12	4.65
Other rolls	.39	—	—	—
Whole wheat rolls	12.59	—	—	.07
French rolls	108.52	.003	.02	.59
Frozen waffles	45.68	.001	.01	.25
Plain muffins	4.45	—	—	.02
Bran muffins	11.81	—	—	.06
English muffins	57.35	.001	.01	.31
Blueberry muffins	23.32	.001	—	.13
Corn muffins	12.29	—	—	.07

Continued on next page

TABLE 1—Continued

Item	1955-57 total expenditure for all families in the panel	Average expenditure per family weekly	Percent of total expenditure for food at home	Percent of subgroup expenditure for food at home
	(dollars)	(dollars)	(percent)	(percent)
Other muffins	3.19	—	—	.02
Coffee cake	1,004.60	.023	.14	5.50
Lady fingers	3.39	—	—	.02
Soda crackers	2,595.50	.061	.37	14.20
Other salted crackers	697.12	.016	.10	3.81
Graham crackers (chocolate covered)	164.96	.004	.02	.90
Graham crackers (not chocolate covered)	1,132.54	.026	.16	6.20
Teething biscuits	13.21	—	—	.07
Other crackers	869.78	.020	.12	4.76
Cracker meal	25.12	.001	—	.14
Angel food cake—iced	62.96	.001	.01	.34
Angel food cake—not iced	484.88	.011	.07	2.65
Cheese cake	81.62	.002	.01	.45
Layer cake—plain frosting	655.76	.015	.09	3.59
Layer cake—chocolate frosting	295.98	.007	.04	1.62
Other layer cake	1.09	—	—	.01
Cup cakes—chocolate frosting	410.55	.010	.06	2.25
Cup cakes—plain frosting	295.89	.007	.04	1.62
Cup cakes—chocolate not frosted	5.63	—	—	.03
Cup cakes—plain not frosted	23.32	.001	—	.13
Waffles, cuplets	.59	—	—	—
Fruit cake	368.42	.009	.05	2.02
Loaf cake—not frosted	77.74	.010	.01	.43
Loaf cake—plain frosting	184.27	.004	.03	1.01
Loaf cake—chocolate frosting	52.59	.001	.01	.29
Other loaf cake	56.37	.001	.01	.31
Sponge cake—no frosting	151.71	.004	.02	.83
Sponge cake—with frosting	31.88	.001	—	.17
Jelly roll	373.15	.009	.05	2.04
Cream Puffs	127.51	.003	.02	.70
Eclairs	120.20	.003	.02	.66
Cookies	**9,947.65**	**.232**	**1.41**	**100.00**
Plain or sugared	3,909.85	.091	.55	39.30
Plain with frosting or marshmallow	1,208.36	.028	.17	12.15
Chocolate	1,155.24	.027	.16	11.61
Chocolate with frosting or marshmallow	738.10	.017	.10	7.42
Fruit filled	1,476.16	.035	.21	14.84
Assorted	1,459.94	.034	.21	14.68
Doughnuts, pies	**6,741.54**	**.155**	**.95**	**100.00**
Raised doughnuts (frosted)	1,329.82	.031	.19	19.73
Raised doughnuts (plain)	496.22	.012	.07	7.36
Cake type—frosted	1,470.96	.034	.21	21.82

TABLE 1—Continued

Item	1955-57 total expenditure for all families in the panel	Average expenditure per family weekly	Percent of total expenditure for food at home	Percent of subgroup expenditure for food at home
	(dollars)	(dollars)	(percent)	(percent)
Cake type—plain	778.11	.018	.11	11.54
Bismarcks	572.41	.013	.08	8.49
Unknown	.60	—	—	.01
Cream pie	122.28	.003	.02	1.81
Custard pie	17.87	—	—	.27
Mincemeat pie	61.80	.001	.01	.92
Pumpkin pie	96.68	.002	.01	1.43
Chiffon pie	18.54	—	—	.28
Other cream pies	34.67	.001	—	.51
Apple pie	591.29	.014	.08	8.77
Apricot pie	11.44	—	—	.17
Blackberry pie	44.75	.001	.01	.66
Blueberry pie	184.13	.004	.03	2.73
Boysenberry pie	17.00	—	—	.25
Cherry pie	506.12	.012	.07	7.51
Peach pie	53.82	.001	.01	.80
Pineapple pie	97.26	.002	.01	1.44
Raisin pie	25.58	.001	—	.38
Raspberry pie	21.29	—	—	.32
Rhubarb pie	36.71	.001	.01	.54
Strawberry pie	24.36	.001	—	.36
Apple-Blueberry pie	44.20	.001	.01	.66
Apple-Cherry pie	23.94	.001	—	.36
Strawberry-Rhubarb pie	13.85	—	—	.21
Other fruit pies	26.72	.001	—	.40
Complete pies (frozen)	19.12	—	—	.28
Mixes	5,672.80	.131	.80	100.00
Cake mix—white	757.64	.018	.11	13.36
Cake mix—yellow	396.73	.009	.06	6.99
Cake mix—chocolate	769.56	.018	.11	13.57
Cake mix—angel food	701.74	.016	.10	12.37
Cake mix—spice	327.23	.008	.05	5.77
Other cake mix	482.52	.011	.07	8.51
Fruit cake mix	1.56	—	—	.03
Cookie mix—plain	26.25	.001	—	.46
Cookie mix—chocolate	101.84	.002	.01	1.80
Brownie mix	249.92	.006	.04	4.41
Frozen cookies	5.16	—	—	.09
Hot roll mix	98.83	.002	.01	1.74
Biscuit mix	418.88	.010	.06	7.38
Corn bread mix	20.74	—	—	.37
Bran bread mix	.15	—	—	—
Plain bread mix	4.97	—	—	.09

Continued on next page

TABLE 1—Continued

Item	1955-57 total expenditure for all families in the panel	Average expenditure per family weekly	Percent of total expenditure for food at home	Percent of subgroup expenditure for food at home
	(dollars)	(dollars)	(percent)	(percent)
Other bread mix	4.05	—	—	.07
Corn muffin mix	93.35	.002	.01	1.65
Bran muffin mix	3.24	—	—	.06
Plain muffin mix	4.01	—	—	.07
Other muffin mix	87.11	.002	.01	1.54
Pie crust mix	315.55	.007	.04	5.56
Complete pie filling and crust mix	28.68	.001	—	.51
Pancake or waffle mix (buckwheat)	97.72	.002	.01	1.72
Pancake or waffle mix (plain)	407.49	.010	.06	7.18
Other pancake mix	90.44	.002	.01	1.59
Pineapple pie mix	.53	—	—	.01
Other mixes	176.91	.004	.03	3.12
Flour, corn meal	**3,800.81**	**.089**	**.54**	**100.00**
Oat flour	1.22	—	—	.03
Barley flour	5.81	—	—	.15
Soya flour	3.76	—	—	.10
Cake flour	160.25	.004	.02	4.22
Graham flour	70.88	.002	.01	1.86
White flour—enriched	3,256.50	.076	.46	85.68
White flour—non-enriched	47.12	.001	.01	1.24
Corn meal	113.05	.003	.02	2.97
Corn starch	83.92	.002	.01	2.21
Rye flour	5.90	—	—	.16
Buckwheat flour	14.34	—	—	.38
Canned mush	10.17	—	—	.27
Whole wheat flour	27.89	.001	—	.73
Spaghetti or macaroni, rice	**3,604.08**	**.082**	**.51**	**100.00**
Spaghetti or macaroni, plain, box	827.01	.019	.12	22.95
Spaghetti or macaroni, box, meat	30.06	.001	—	.83
Spaghetti or macaroni, box, meat sauce	69.04	.002	.01	1.92
Spaghetti or macaroni, box, cheese	114.34	.003	.02	3.17
Spaghetti or macaroni, box, tomato	13.95	—	—	.39
Chef Boy-ar-dee	83.81	.002	.01	2.33
Spaghetti or macaroni, can, plain	11.21	—	—	.31
Spaghetti or macaroni, can, meat	43.65	.001	.01	1.21
Spaghetti or macaroni, can, meat sauce	56.64	.001	.01	1.57
Spaghetti or macaroni, can, cheese	294.43	.007	.04	8.17
Spaghetti or macaroni, can, tomato	338.72	.008	.05	9.40
Spaghetti or macaroni, can, other	18.20	—	—	.50
Spaghetti or macaroni, bag, plain	433.60	.010	.06	12.03
Spaghetti or macaroni, bag, meat	1.74	—	—	.05
Spaghetti or macaroni, bag, meat sauce	.27	—	—	.01

TABLE 1—Continued

Item	1955-57 total expenditure for all families in the panel	Average expenditure per family weekly	Percent of total expenditure for food at home	Percent of subgroup expenditure for food at home
	(dollars)	(dollars)	(percent)	(percent)
Spaghetti or macaroni, bag, tomato	3.07	—	—	.09
Spaghetti or macaroni, bag, other	7.77	—	—	.22
Macaroni and cheese (frozen)	14.43	—	—	.40
Spaghetti pies	3.44	—	—	.10
Macaroni and cheese	7.05	—	—	.20
Noodles, box, plain	40.22	.001	.01	1.12
Noodles, box, meat	.13	—	—	—
Noodles, box, meat sauce	.25	—	—	.01
Noodles, box, other	4.70	—	—	.13
Noodles, can, plain	8.60	—	—	.24
Noodles, can, meat	3.61	—	—	.10
Noodles, can, meat sauce	.49	—	—	.01
Noodles, can, cheese	.56	—	—	.02
Noodles, can, tomato	1.66	—	—	.05
Noodles, can, other	134.00	.003	.02	3.72
Noodles, bag, plain	341.99	.008	.05	9.49
Noodles, bag, cheese	.48	—	—	.01
Noodles, bag, other	7.34	—	—	.20
Noodles, soup, dried	.41	—	—	.01
Rice, box, plain	152.28	.004	.02	4.23
Rice, box, meat	.25	—	—	.01
Rice, box, tomato	.61	—	—	.02
Rice, box, other	71.30	.002	.01	1.98
Minute Rice	110.67	.003	.02	3.07
Rice, can, plain	1.64	—	—	.05
Rice, can, meat	19.54	—	—	.54
Rice, can, meat sauce	1.98	—	—	.05
Rice, can, cheese	.65	—	—	.02
Rice, can, tomato	18.06	—	—	.50
Rice, can, other	5.63	—	—	.16
Rice, bag, plain	162.12	.004	.02	4.50
Rice, bag, tomato	.58	—	—	.02
Rice, bag, other	2.43	—	—	.07
Hominy	11.56	—	—	.32
Tapioca	81.53	.002	.01	2.26
Wheat germ	46.38	.001	.01	1.29
Appetizers, etc	1,225.08	.027	.17	100.00
Crackerjacks	98.43	.002	.01	8.03
Cheese twist, cheese sticks, corn pones	138.98	.003	.02	11.34
Popped corn, fritos	98.10	.002	.01	8.01
Pop corn—raw	591.39	.014	.08	48.27
Pretzels	176.78	.004	.02	14.43
Bacon rinds	19.96	—	—	1.63

Continued on next page

TABLE 1—Continued

Item	1955-57 total expenditure for all families in the panel	Average expenditure per family weekly	Percent of total expenditure for food at home	Percent of subgroup expenditure for food at home
	(dollars)	(dollars)	(percent)	(percent)
Bread sticks	15.13	—	—	1.24
Cones for ice cream	80.63	.002	.01	6.58
Grits	1.02	—	—	.08
Blue cheese crackers	.54	—	—	.04
Barley for soup	1.14	—	—	.09
Wild rice	1.98	—	—	.16
Whole soya bean	1.00	—	—	.08
Sugar, sweets, candy	**21,649.75**	**.433**	**3.06**	**100.00**
White or powdered	7,886.08	.184	1.11	36.43
Dextrose, maltose	72.31	.002	.01	.33
Tasti Diet	1.94	—	—	.01
Sucaryl sugar	74.48	.002	.01	.34
Saccharine	6.30	—	—	.03
Sucaryl	12.66	—	—	.06
Brown sugar	973.61	.023	.14	4.50
Maple sugar	6.18	—	—	.03
Corn syrup	298.00	.007	.04	1.38
Cane syrup	213.97	.005	.03	.99
Maple syrup	506.49	.012	.07	2.34
Molasses	164.67	.004	.02	.76
Sorghum	26.29	.001	—	.12
Other syrup	451.11	.011	.06	2.08
Topping for ice cream	325.91	.008	.05	1.51
Honey	615.41	.014	.09	2.84
Fondant, mint, marshmallow candy	955.29	.022	.14	4.41
Cream—chocolate covered candy	791.68	.019	.11	3.66
Cream—fruit, nut candy	328.28	.008	.05	1.52
Cream—chocolate, fruit, nut candy	772.86	.018	.11	3.57
Solid chocolate candy	797.64	.019	.11	3.68
Other candy and sweets	3,151.82	.074	.45	14.56
Gelatin—unflavored	161.86	.004	.02	.75
Flavored gelatin	1,451.74	.034	.21	6.71
Puddings, pie filling	978.79	.023	.14	4.52
Puddings, (baby food)	256.04	.006	.04	1.18
Diet pudding	4.64	—	—	.02
Candy mix	30.32	.001	—	.14
Frosting mix	332.99	.008	.05	1.54
Frozen chocolate malt	.39	—	—	—
Nuts	**7,475.34**	**.174**	**1.06**	**100.00**
Coconut in shell	17.44	—	—	.23
Coconut shelled	125.15	.003	.02	1.67
Coconut canned	46.93	.001	.01	.63

TABLE 1—Continued

Item	1955-57 total expenditure for all families in the panel	Average expenditure per family weekly	Percent of total expenditure for food at home	Percent of subgroup expenditure for food at home
	(dollars)	(dollars)	(percent)	(percent)
Peanuts in shell	236.97	.006	.04	3.17
Peanuts shelled	743.15	.017	.10	9.94
Peanuts canned	42.40	.001	.01	.57
Peanut butter	2,934.61	.069	.42	39.26
Almonds in shell	18.68	—	—	.25
Almonds shelled	75.36	.002	.01	1.01
Almonds canned	7.65	—	—	.10
Brazil nuts in shell	41.27	.001	.01	.55
Brazil nuts shelled	19.37	—	—	.26
Brazil nuts canned	2.26	—	—	.03
Walnuts, pecans in shell	532.35	.012	.07	7.12
Walnuts, pecans shelled	1,370.04	.032	.19	18.33
Walnuts, pecans canned	85.24	.002	.01	1.14
Mixed nuts in shell	237.94	.006	.04	3.18
Mixed nuts shelled	436.65	.010	.06	5.84
Mixed nuts canned	57.46	.001	.01	.77
Other nuts in shell	72.68	.002	.01	.97
Other nuts shelled	349.73	.008	.05	4.68
Other nuts canned	22.01	.001	—	.29
Vitamins, minerals	**10,033.51**	**.235**	**1.42**	**100.00**
Vitamins	9,048.78	.212	1.28	90.19
Minerals	984.73	.023	.14	9.81
Cooking aids	**4,527.24**	**.105**	**.64**	**100.00**
Baking powder	130.62	.003	.02	2.89
Baking soda	107.72	.003	.02	2.38
Chocolate—baking, chocolate chips	866.54	.020	.12	19.14
Extract	399.79	.009	.05	8.83
Meat sauce	265.07	.006	.04	5.86
Junket tablets	3.44	—	—	.08
Salt	487.27	.011	.07	10.76
Spices	568.15	.013	.08	12.55
Pepper	294.21	.007	.04	6.50
Canning aids (Certo)	155.53	.004	.02	3.44
Vinegar	516.70	.012	.07	11.41
Yeast	204.26	.005	.03	4.51
Cream of tartar	12.33	—	—	.27
Meat tenderizer	61.37	.001	.01	1.36
Mustard—prepared	453.89	.011	.07	10.03
Unclassified	.35	—	—	.01
Fresh fruit	**33,237.01**	**.777**	**4.70**	**100.00**
Blueberries	623.03	.015	.09	1.87

Continued on next page

TABLE 1—Continued

Item	1955-57 total expenditure for all families in the panel	Average expenditure per family weekly	Percent of total expenditure for food at home	Percent of subgroup expenditure for food at home
	(dollars)	(dollars)	(percent)	(percent)
Cranberries	247.59	.006	.03	.74
Currants	10.58	—	—	.03
Dewberries and blackberries	42.94	.001	.01	.13
Raspberries	772.53	.018	.11	2.32
Strawberries	2,437.19	.057	.34	7.33
Other berries	24.11	.001	—	.07
Berry juice	.70	—	—	—
Grapefruit	2,570.90	.060	.36	7.74
Lemons	696.45	.016	.10	2.10
Limes	32.20	.001	—	.10
Oranges	4,312.49	.101	.61	12.97
Orange juice	571.18	.013	.08	1.72
Tangerines	488.74	.011	.07	1.47
Other citrus	31.85	.001	—	.10
Mixed citrus fruit	32.19	.001	—	.10
Apples	5,510.09	.129	.78	16.58
Apricots	36.61	.001	.01	.11
Avocados	113.82	.003	.02	.34
Bananas	7,118.97	.166	1.01	21.42
Cherries (sour)	144.31	.003	.02	.43
Cherries (sweet)	204.10	.005	.03	.61
Figs	11.20	—	—	.03
Grapes	1,242.98	.029	.18	3.74
Cantaloupe and muskmelon	1,755.16	.041	.25	5.28
Watermelon	1,141.74	.027	.16	3.44
Nectarines	33.84	.001	—	.10
Persimmons	7.54	—	—	.02
Olives	13.68	—	—	.04
Peaches	1,847.51	.043	.26	5.56
Pears	554.81	.013	.08	1.67
Pineapple	140.49	.003	.02	.42
Plums	374.48	.009	.05	1.13
Rhubarb	66.67	.002	.01	.20
Other fruit	4.90	—	—	.01
Waldorf salad	2.48	—	—	.01
Unclassified	16.96	—	—	.05
Frozen fruit	**11,155.00**	**.259**	**1.58**	**100.00**
Blueberries	36.77	.001	.01	.33
Cranberries	1.78	—	—	.02
Cranberry and orange	14.18	—	—	.13
Dewberry and blackberry	5.39	—	—	.05
Raspberries	198.05	.005	.03	1.78
Strawberries	1,632.07	.038	.23	14.63

TABLE 1—Continued

Item	1955-57 total expenditure for all families in the panel	Average expenditure per family weekly	Percent of total expenditure for food at home	Percent of subgroup expenditure for food at home
	(dollars)	(dollars)	(percent)	(percent)
Other berries	7.85	—	—	.07
Grapefruit	53.31	.001	.01	.48
Grapefruit juice	153.45	.004	.02	1.38
Lemonade	592.76	.014	.08	5.31
Lemon juice	94.50	.002	.01	.85
Lime juice	2.69	—	—	.02
Limeade	79.44	.002	.01	.71
Oranges	14.53	—	—	.13
Orangeade	3.10	—	—	.03
Orange juice	7,276.79	.170	1.03	65.23
Tangerine juice	61.95	.001	.01	.56
Other citrus juice	7.01	—	—	.06
Mixed citrus fruit	9.49	—	—	.09
Mixed citrus juice	46.36	.001	.01	.42
Apples	2.22	—	—	.02
Apricots	1.13	—	—	.01
Cherries (sour)	150.89	.004	.02	1.35
Cherries (sweet)	18.90	—	—	.17
Grape juice, concentrate	397.21	.009	.06	3.56
Cantaloupe and muskmelon	26.57	.001	—	.24
Watermelon	.35	—	—	—
Peaches	57.09	.001	.01	.51
Pineapple	50.14	.001	.01	.45
Pineapple juice	108.60	.003	.02	.97
Rhubarb	29.82	.001	—	.27
Hawaiian punch base	4.83	—	—	.04
Mixed fruit juices	6.96	—	—	.06
Other fruit juces	1.36	—	—	.01
Waldorf salad	3.26	—	—	.03
Fruit cocktail	4.20	—	—	.04
Canned fruit	**16,873.43**	**.392**	**2.39**	**100.00**
Blueberries	171.86	.004	.02	1.02
Cranberries	241.30	.006	.03	1.43
Currants	1.58	—	—	.01
Dewberry and blackberry	20.72	—	—	.12
Raspberries	68.75	.002	.01	.41
Strawberries	32.95	.001	—	.20
Other berries	18.02	—	—	.11
Berry juice	.79	—	—	—
Grapefruit	614.48	.014	.09	3.64
Grapefruit juice	290.97	.007	.04	1.72
Lemonade	23.79	.001	—	.14
Lemon juice	183.25	.004	.03	1.09

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TABLE 1—Continued

Item	1955-57 total expenditure for all families in the panel	Average expenditure per family weekly	Percent of total expenditure for food at home	Percent of subgroup expenditure for food at home
	(dollars)	(dollars)	(percent)	(percent)
Lime juice (single strength)	13.04	—	—	.08
Lime juice, concentrate	4.47	—	—	.03
Limeade	2.23	—	—	.01
Oranges	100.86	.002	.01	.60
Orange drink	412.01	.010	.06	2.44
Orange juice, concentrate	82.51	.002	.01	.49
Orange juice, (single strength)	513.56	.012	.07	3.04
Tangerines	11.40	—	—	.07
Tangerine juice	45.27	.001	.01	.27
Other citrus	8.03	—	—	.05
Other citrus juice	14.85	—	—	.09
Mixed citrus fruit	133.72	.003	.02	.79
Mixed citrus juice	197.25	.005	.03	1.17
Applesauce and applebutter	938.38	.022	.13	5.56
Apple cider	332.69	.008	.05	1.97
Apple juice	219.05	.005	.03	1.30
Apricots	680.81	.016	.10	4.03
Apricot nectar	216.31	.005	.03	1.28
Cherries—maraschino	254.26	.006	.04	1.51
Cherries (sour)	426.09	.010	.06	2.53
Cherries (sweet)	269.03	.006	.04	1.59
Dates	.72	—	—	—
Figs	37.25	.001	.01	.22
Fig juice	2.37	—	—	.01
Grapes	14.97	—	—	.09
Grape juice, concentrate	27.31	.001	—	.16
Grape juice (single strength)	447.12	.010	.06	2.65
Cantaloupe and Muskmelon	.29	—	—	—
Watermelon	.87	—	—	.01
Nectarines	4.87	—	—	.03
Persimmons	3.97	—	—	.02
Olives	1,384.07	.032	.20	8.20
Peaches	2,018.13	.047	.29	11.96
Pears	1,121.00	.026	.16	6.64
Pineapple	2,023.83	.047	.29	11.99
Pineapple juice	423.62	.010	.06	2.51
Plums	272.70	.006	.04	1.62
Prunes	85.80	.002	.01	.51
Prune juice	477.69	.011	.07	2.83
Rhubarb	2.97	—	—	.02
Other fruit	4.99	—	—	.03
Hawaiian punch base	99.04	.002	.01	.59
Mixed fruit juice	325.44	.008	.05	1.93
Other fruit juice	22.91	.001	—	.14

TABLE 1—Continued

Item	1955-57 total expenditure for all families in the panel	Average expenditure per family weekly	Percent of total expenditure for food at home	Percent of subgroup expenditure for food at home
	(dollars)	(dollars)	(percent)	(percent)
Fruit pickles	113.02	.003	.02	.67
Waldorf salad	117.62	.003	.02	.70
Fruit cocktail	1,295.99	.030	.18	7.68
Unclassified	.58	—	—	—
Dried fruit	**2,072.09**	**.048**	**.29**	**100.00**
Currants	24.61	.001	—	1.19
Apples	2.77	—	—	.13
Apricots	104.02	.002	.01	5.02
Bananas	.73	—	—	.04
Dates	491.05	.011	.07	23.70
Figs	100.75	.002	.01	4.86
Peaches	21.71	.001	—	1.05
Prunes	718.72	.017	.10	34.69
Raisins	593.93	.014	.08	28.66
Other fruit	1.66	—	—	.08
Powdered juice	3.46	—	—	.17
Mixed fruits	8.68	—	—	.42
Jams and jellies	**2,005.61**	**.047**	**.28**	**100.00**
Blueberries	23.86	.001	—	1.19
Cranberries	15.16	—	—	.76
Currants	32.53	.001	—	1.62
Dewberries and blackberries	27.44	.001	—	1.37
Raspberries	256.56	.006	.04	12.79
Strawberries	477.39	.011	.07	23.80
Other berries	132.80	.003	.02	6.62
Mint jelly	1.33	—	—	.07
Unknown jelly	10.21	—	—	.50
Lime jelly	.25	—	—	.01
Orange	75.21	.002	.01	3.75
Other citrus	.93	—	—	.05
Apple jelly	97.90	.002	.01	4.88
Apricot	35.06	.001	.01	1.75
Cherry	98.34	.002	.01	4.90
Grape	451.69	.011	.06	22.52
Peach	47.74	.001	.01	2.38
Pear	.73	—	—	.04
Pineapple	53.81	.001	.01	2.68
Plum	45.38	.001	.01	2.26
Other fruit	47.93	.001	.01	2.39
Mixed fruit	73.36	.002	.01	3.66

Continued on next page

TABLE 1—Continued

Item	1955-57 total expenditure for all families in the panel	Average expenditure per family weekly	Percent of total expenditure for food at home	Percent of subgroup expenditure for food at home
	(dollars)	(dollars)	(percent)	(percent)
Prepared fruit	**58.50**	**.001**	**.01**	**100.00**
Fruit gelatin salad	58.11	.001	.01	99.33
Mixed fruits	.39	—	—	.67
Candied fruit	**165.06**	**.004**	**.02**	**100.00**
Cranberries	5.72	—	—	3.47
Figs	.63	—	—	.38
Pears	.64	—	—	.39
Candied fruit	157.70	.004	.02	95.54
Fruit pickles	.37	—	—	.22
Fruit pie mix	**270.37**	**.006**	**.04**	**100.00**
Blueberry	44.59	.001	.01	16.49
Dewberry and blackberry	5.95	—	—	2.20
Raspberry	6.41	—	—	2.37
Strawberry	.94	—	—	.35
Other berry	.58	—	—	.21
Apple	47.98	.001	.01	17.75
Apricot	.33	—	—	.12
Cherry	92.26	.002	.01	34.12
Sweet cherry	2.86	—	—	1.06
Peaches	21.93	.001	—	8.11
Pineapple	12.61	—	—	4.66
Raisin	5.98	—	—	2.21
Fruit pie mix	27.95	.001	—	10.34
Baby food—fruit	**1,776.77**	**.041**	**.25**	**100.00**
Orange juice	194.40	.005	.03	10.94
Applesauce	255.85	.006	.04	14.40
Apple juice	39.16	.001	.01	2.20
Apricots	55.00	.001	.01	3.10
Bananas	114.10	.003	.02	6.42
Peaches	233.69	.005	.03	13.15
Pears	153.86	.004	.02	8.66
Pineapple juice	2.46	—	—	.14
Plums	83.76	.002	.01	4.71
Prunes	82.45	.002	.01	4.64
Raisins	.15	—	—	.01
Other fruit	68.55	.002	.01	3.86
Other fruit juice	3.63	—	—	.20
Mixed fruits	110.99	.003	.02	6.25
Apple and apricot	96.80	.002	.01	5.45
Pear-pineapple	151.77	.004	.02	8.54
Other mixed	20.16	—	—	1.13

TABLE 1—Continued

Item	1955-57 total expenditure for all families in the panel	Average expenditure per family weekly	Percent of total expenditure for food at home	Percent of subgroup expenditure for food at home
	(dollars)	(dollars)	(percent)	(percent)
Apricot-farina	15.92	—	—	.90
Plum-farina	19.28	—	—	1.09
Apricot-oatmeal	9.88	—	—	.56
Other mixed	17.29	—	—	.97
Orange-apricot juice	20.75	—	—	1.17
Orange-prune juice	26.77	.001	—	1.51
Orange-apple juice	.10	—	—	.01
Fresh vegetables	30,697.49	.717	4.34	100.00
Brussel sprouts	111.36	.003	.02	.36
Cabbage	1,217.61	.028	.17	3.97
Sauerkraut	46.80	.001	.01	.15
Cabbage salad	3.59	—	—	.01
Celery	2,722.16	.064	.38	8.87
Celery cabbage	116.09	.003	.02	.38
Endive, chicory	70.93	.002	.01	.23
Head lettuce	5,629.09	.132	.80	18.34
Leaf lettuce	139.85	.003	.02	.46
Bibb lettuce	52.64	.001	.01	.17
Oak lettuce	.38	—	—	—
Greens, beets, mustard	49.73	.001	.01	.16
Parsley, Swiss chard	36.32	.001	.01	.12
Spinach	274.73	.006	.04	.89
Mixed leafy vegetables	88.63	.002	.01	.29
Other leafy vegetables	25.07	.001	—	.08
Artichokes	12.27	—	—	.04
Asparagus	452.35	.011	.06	1.47
Lima Beans	13.51	—	—	.04
Lima beans (in pod)	12.40	—	—	.04
Beans—snap	203.22	.005	.03	.66
Bean sprouts	4.12	—	—	.01
Broccoli	193.09	.005	.03	.63
Carrots	1,919.90	.045	.27	6.25
Corn—sweet	954.55	.022	.13	3.11
Peas	8.08	—	—	.03
Peas (in pod)	86.17	.002	.01	.28
Peppers	725.24	.017	.10	2.36
Pumpkin	17.34	—	—	.06
Squash	298.91	.007	.04	.97
Yams and sweet potatoes	445.59	.010	.06	1.45
Mixed green and yellow vegetables	7.05	—	—	.02
Beets	49.75	.001	.01	.16
Cauliflower	503.82	.012	.07	1.64
Cucumbers	1,015.32	.024	.14	3.31

Continued on next page

TABLE 1—Continued

Item	1955-57 total expenditure for all families in the panel	Average expenditure per family weekly	Percent of total expenditure for food at home	Percent of subgroup expenditure for food at home
	(dollars)	(dollars)	(percent)	(percent)
Cucumber pickles	2.56	—	—	.01
Egg plant	41.24	.001	.01	.13
Garlic	.47	—	—	—
Horseradish	.48	—	—	—
Pimentoes	.96	—	—	—
Mushrooms	21.31	—	—	.07
Green onions	473.88	.011	.07	1.54
Oyster plant	1.18	—	—	—
Parsnips	143.80	.003	.02	.47
Potatoes—Michigan	4,059.49	.095	.57	13.22
Potatoes—Maine	597.40	.014	.08	1.95
Potatoes—Idaho	1,270.17	.030	.18	4.14
Potatoes—California	1,072.31	.025	.15	3.49
Potatoes—other state	573.35	.013	.08	1.87
Potatoes—state unknown	944.33	.022	.13	3.08
Radishes	578.25	.014	.08	1.88
Tomatoes	3,229.20	.076	.46	10.52
Tomato juice	.49	—	—	—
Turnips and rutabagas	172.17	.004	.02	.56
Other vegetables	4.85	—	—	.02
Mixed vegetables	1.94	—	—	.01
Frozen vegetables	**4,101.64**	**.097**	**.58**	**100.00**
Brussel sprouts	196.31	.005	.03	4.79
Greens, beets, mustard	23.19	.001	—	.57
Spinach	193.01	.005	.03	4.71
Mixed leafy vegetables	1.19	—	—	.03
Other leafy vegetables	5.19	—	—	.13
Artichokes	2.01	—	—	.05
Asparagus	195.29	.005	.03	4.76
Lima beans	264.61	.006	.04	6.45
Beans, snap	345.05	.008	.05	8.41
Bean sprouts	6.84	—	—	.17
Broccoli	425.31	.010	.06	10.37
Carrots	2.84	—	—	.07
Corn—sweet	256.59	.006	.04	6.26
Peas	837.35	.020	.12	20.42
Peppers	.96	—	—	.02
Pumpkin	1.76	—	—	.04
Squash	220.16	.005	.03	5.37
Yams and sweet potatoes	31.45	.001	—	.77
Mixed green and yellow vegetables	255.27	.006	.04	6.22
Beans, navy, baked, white	2.17	—	—	.05
Beans, kidney	.31	—	—	.01

TABLE 1—Continued

Item	1955-57 total expenditure for all families in the panel	Average expenditure per family weekly	Percent of total expenditure for food at home	Percent of subgroup expenditure for food at home
	(dollars)	(dollars)	(percent)	(percent)
Beets	2.99	—	—	.07
Cauliflower	203.29	.005	.03	4.96
Onions	8.50	—	—	.21
Potatoes—Idaho	3.20	—	—	.08
Potatoes—other state	.33	—	—	.01
Potatoes—state unknown	9.05	—	—	.22
Mashed potato and patties	27.65	.001	—	.67
Potatoes—french fries	485.42	.011	.07	11.83
Potato sticks	3.84	—	—	.09
Tomato juice	10.02	—	—	.24
Other vegetables	9.04	—	—	.22
Mixed vegetables	65.25	.002	.01	1.59
Soya steak and choplets	1.46	—	—	.04
Mixed vegetable juice	.25	—	—	.01
Chop suey, chow mein	4.49	—	—	.11
Canned vegetables	18,841.91	.440	2.66	100.00
Brussel sprouts	2.42	—	—	.01
Cabbage	9.73	—	—	.05
Sauerkraut	334.67	.008	.05	1.78
Cabbage salad	1.83	—	—	.01
Endive, chicory	.35	—	—	—
Greens, beets and mustard	30.76	.001	—	.16
Swiss chard, parsley	2.27	—	—	.01
Spinach	331.43	.008	.05	1.76
Mixed leafy vegetables	2.53	—	—	.01
Other leafy vegetables	8.83	—	—	.05
Artichokes	5.43	—	—	.03
Asparagus	627.53	.015	.09	3.33
Lima beans	394.50	.009	.06	2.09
Beans, snap	1,802.35	.042	.25	9.57
Bean sprouts	151.88	.004	.02	.81
Broccoli	4.79	—	—	.03
Carrots	62.58	.001	.01	.33
Corn—sweet	1,907.33	.045	.27	10.12
Peas	1,743.89	.041	.25	9.26
Peppers	38.80	.001	.01	.21
Pumpkin	278.63	.007	.04	1.48
Squash	3.83	—	—	.02
Yams and sweet potatoes	275.97	.006	.04	1.46
Mixed green and yellow vegetables	201.72	.005	.03	1.07
Soya steak and choplets	1.14	—	—	.01
Beans—baked, pork and beans	1,329.17	.031	.19	7.05
Beans, kidney	703.25	.016	.10	3.73

Continued on next page

TABLE 1—Continued

Item	1955-57 total expenditure for all families in the panel	Average expenditure per family weekly	Percent of total expenditure for food at home	Percent of subgroup expenditure for food at home
	(dollars)	(dollars)	(percent)	(percent)
Beets	497.88	.012	.07	2.64
Cauliflower	4.65	—	—	.02
Pickles and relish	688.21	.016	.10	3.65
Cucumber pickles	1,219.32	.029	.17	6.47
Relish	235.63	.006	.03	1.25
Egg plant	.82	—	—	—
Horseradish	175.79	.004	.02	.93
Pimentoes	35.00	.001	.01	.19
Mushrooms	705.05	.016	.10	3.74
Onions	46.12	.001	.01	.24
Parsnips	.34	—	—	—
Potatoes—Michigan	11.81	—	—	.06
Potatoes—Maine	4.81	—	—	.03
Potatoes—Idaho	4.52	—	—	.02
Potatoes—California	2.23	—	—	.01
Potatoes—other state	42.19	.001	.01	.22
Potatoes—state unknown	236.65	.006	.03	1.26
Potato sticks	26.53	.001	—	.14
Potato salad	11.38	—	—	.06
Tomatoes	923.12	.022	.13	4.90
Tomato catsup, sauce	2,153.01	.050	.30	11.43
Tomato juice	903.91	.021	.13	4.80
Turnips and rutabagas	7.35	—	—	.04
Other vegetables	38.81	.001	.01	.21
Mixed vegetables	104.80	.002	.01	.56
Unclassified	17.12	—	—	.09
Mixed vegetable juices	266.18	.006	.04	1.41
Chop suey, chow mein	207.09	.005	.03	1.10
Mixed vegetable chop suey, chow mein	13.98	—	—	.07
Dried vegetables	**6,724.95**	**.157**	**.95**	**100.00**
Celery	.68	—	—	.01
Parsley, water cress	8.06	—	—	.12
Beans, lima	34.39	.001	—	.51
Corn	.79	—	—	.01
Peas	36.21	.001	—	.54
Mixed green and yellow vegetables	3.45	—	—	.05
Beans—navy, white	564.33	.013	.08	8.39
Beans—kidney	22.73	.001	.01	.34
Beans—pre-cooked	8.34	—	—	.12
Garlic	34.12	.001	—	.51
Horseradish	.39	—	—	.01
Mushrooms	12.42	—	—	.18
Onions—mature	1,623.14	.038	.23	24.14

TABLE 1—Continued

Item	1955-57 total expenditure for all families in the panel	Average expenditure per family weekly	Percent of total expenditure for food at home	Percent of subgroup expenditure for food at home
	(dollars)	(dollars)	(percent)	(percent)
Potatoes—Idaho	.29	—	—	—
Potatoes—other state	.39	—	—	.01
Potatoes—state unknown	50.11	.001	.01	.75
Mashed potatoes and patties	17.78	—	—	.26
Potato chips	4,234.77	.099	.60	62.97
Potato sticks	70.23	.002	.01	1.04
Tomato paste, sauces	.49	—	—	.01
Other vegetables	1.84	—	—	.03
Soup—vegetable	**4,411.61**	**.103**	**.62**	**100.00**
Celery	96.45	.002	.01	2.19
Asparagus	39.55	.001	.01	.90
Corn	.35	—	—	.01
Pea	233.47	.005	.03	5.29
Bean	249.26	.006	.04	5.65
Mushroom	740.48	.017	.10	16.78
Onion	77.90	.002	.01	1.77
Potato	51.64	.001	.01	1.17
Tomato	1,436.17	.034	.20	32.55
Other	118.80	.003	.02	2.69
Unclassified	15.14	—	—	.34
Vegetable	1,352.40	.032	.19	30.67
Prepared vegetables	**967.94**	**.022**	**.14**	**100.00**
Cabbage salad	37.68	.001	.01	3.89
Lima beans	.48	—	—	.05
Corn	16.80	—	—	1.74
Squash	.35	—	—	.04
Beans—navy, baked	204.34	.005	.03	21.11
Beans—kidney	.39	—	—	.04
Pickles and relish	.29	—	—	.03
Cucumber pickles	7.76	—	—	.80
Potatoes—state unknown	3.47	—	—	.36
Potatoes—french fries	1.80	—	—	.19
Potato salad	662.60	.015	.09	68.45
Mixed vegetables	.39	—	—	.04
Chop suey, chow mein	1.22	—	—	.13
Vegetable gelatin salad	30.37	.001	—	3.14
Juices—vegetable	**18.87**	**—**	**—**	**100.00**
Sauerkraut	5.52	—	—	29.25
Celery	3.52	—	—	18.65
Carrot	8.96	—	—	47.48
Beet	.87	—	—	4.61

Continued on next page

TABLE 1—Concluded

Item	1955-57 total expenditure for all families in the panel	Average expenditure per family weekly	Percent of total expenditure for food at home	Percent of subgroup expenditure for food at home
	(dollars)	(dollars)	(percent)	(percent)
Prepared pie mix	**2.72**	—	—	**100.00**
Pumpkin	2.72	—	—	100.00
Baby food—vegetables	**842.16**	**.019**	**.12**	**100.00**
Spinach	14.74	—	—	1.75
Green beans	73.97	.002	.01	8.78
Carrots	96.61	.002	.01	11.47
Peas	60.28	.001	.01	7.16
Squash	75.37	.002	.01	8.95
Sweet potato	78.51	.002	.01	9.32
Beets	37.16	.001	.01	4.41
Unclassified	.25	—	—	.03
Other vegetables	19.20	—	—	2.28
Mixed vegetables	94.31	.002	.01	11.20
Vegetable and meat soup	268.74	.006	.04	31.91
Soup	23.02	.001	—	2.73

FERTILITY PERCENTAGE OF HENS NOT A GOOD INDEX OF HATCHING POWER

By EARL W. HENDERSON

POULTRY SCIENCE DEPARTMENT

HATCHERY OPERATORS are well aware that efficiency of the hatching process depends not only on the mechanics of incubator operation but also upon reproductive competence of domestic fowl. It has been amply demonstrated that at least a part of reproductive competence is inherited. Environment of flocks and hatchery operation are important factors in the measurement of competence.

Results in this report are from a long-time research project designed to determine the influence of inheritance on hatching power. The findings suggest that in order to improve hatchability by breeding, incubator operations should include two separate records—one for fertility and another for hatchability of fertile eggs. Better still, for most efficient results with breeding flocks, records should be kept of the hatching performance of individually pedigreed hens and eggs. Such records are necessary to provide information from which reliable conclusions may be drawn.

A Distinction Between Commercial and Research Objectives

Many commercial hatchery operators record their hatching results in terms of proportion of total chicks hatched from a given number of eggs set. Fertility and hatchability rates have been presumed to be related for the obvious reason that an egg must be fertilized before it can be hatched.[1] A fertile egg may not hatch, however, for reasons which may not be remotely related to the fertility rate of its parents. It generally is not recognized that reproductive fitness of hens depends upon at least two biological functions, fertility and hatchability. These functions may depend on different sets of factors.

[1]Except in the case of the phenomenon of apomixis (discovered among turkeys at the USDA).

ARTICLE 42-87

Previous Investigations

The variable nature of the relationship between fertility and hatchability has been evident in previous investigations. Dr. M. A. Jull[2] reviewed the research reports of the problem prior to 1952. From 10 separate reports he found that results were evenly divided—five for and five against. One of the most recent systematic research reports[3] indicated no relationship between fertility and hatchability, but an opposite view appears in a book edited by one of the authors.[4] Most recently some Iowa researchers[5] reported a nonsignificant correlation between fertility and hatchability.

Perhaps one of the reasons for the apparent conflict between research findings and popular opinions depends upon the degree of precision in distinguishing unfertilized eggs from very early dead germs. It is well known that very early "dead germs" may disintegrate before candling time. Abnormal opaque flecks of material in the albumen of eggs, known as "meat spots," may be confused with "dead germs." The small amount of error possible from such causes would vary with the experience and proficiency of the candler.

Purposes of this Investigation

Purposes of this investigation are (1) To measure the degree of association (correlation) between the fertility rate of 299 individual hens and hatching rate of their fertile eggs. (2) To evaluate statistically, the implications of any correlation which might be found useful in the solution of hatching problems.

The reason for limiting the study to records of individually pedigreed hens and eggs was to provide data for valid statistical analysis, which would not be possible from mass averages.

MATERIALS AND METHODS

Materials utilized were individual hatching records of 299 randomly selected pedigreed hens from among the 1959 flock population. Total population consisted of approximately 1,000 hens of a

[2]Jull, M. A. (1952). *Poultry Breeding*, 398 pp., John Wiley & Sons, New York.

[3]Bernier, P. E., L. W. Taylor and C. A. Gunns (1951). The relative effects of inbreeding and outbreeding on reproduction in the domestic fowl, Hilgardia 20:529-628.

[4]Taylor, L. W., et al. (1956). *Fertility and Hatchability of Chicken and Turkey Eggs*, 423 pp., John Wiley & Sons, New York.

[5]Nordskog, A. W., L. T. Smith and R. E. Phillips (1959). Crossbreds versus top-crossbred, Poultry Sci. 38:1372-1380.

meat type cross variety. They were maintained at the Michigan State University Poultry Farm incident to Experiment Station Project No. 266.[6]

Criteria for selection of individual records included a hatchability record from five or more fertile eggs. About 90 percent of the records selected included eight or more eggs set. The reason for including records of no less than five fertile eggs was to reduce the chances of artificial distortion of percentage computations resulting from low-base numbers. For example, a single egg from a hen either hatches or it doesn't and yields a percentage of either 100 or zero. In other words, a single egg cannot be an adequate measure of the genetic capabilities of an individual hen. No records with less than six eggs set were included. Flock averages would have been irrelevant to the problem.

Uniformity of Environment—Management

All of the hens from which the trap nest and hatching records were compiled were managed[7] in confinement in the same house in a uniform manner and given identical feed mixtures in automatic self feeders. All matings were the "single male, trap-nest pedigree type". All eggs were set in the same kind of incubators, operated in a reasonably optimum manner.

Fertility was determined by candling on the 18th day of incubation. In so far as possible, "dead germs" were distinguished from "infertiles" by a second candling of the "clear" eggs. A small error in judgment is possible by this method, but it is doubtful if the judgment of experienced candlers would be improved much by observations of the broken out appearance of incubated eggs. All eggs were subjected to the same procedure and it was assumed that chances of error were nearly equal with each "clear" egg.

RESULTS AND DISCUSSION

Average of individual fertility rates was 83 percent. Average of the individual hatchability rates was 87 percent. A total of 5,688 eggs were set; 4,527 eggs were fertile (80 percent) and 4,205 chicks were hatched (93 percent). In spite of the apparent close relationship between average percentage of fertile and percentage hatched, the in-

[6] "Single male" mating and individual pedigree hatching is routine in this project.

[7] Dr. H. C. Zindel, Head of the Poultry Science Department, was responsible for the management program.

dividual variation was such that the statistically calculated correlation rate was only (.09 ± .06). This was a little too low to be statistically significant. A significant correlation with 300 hens would be (.11). The result indicates that attempts to select hens for high hatching power by means of their fertility rate alone would be futile. Chances of being wrong about one third of the time would be possible.

The unreliability of fertility rate as an index of hatching power is further indicated by a "common sense" observation of detailed data and of Table 1. There were only 27 of the 299 cases in which there

TABLE 1—Average relationship between fertility percentage and hatching percentage

Number hens	Range in average percentage of fertile eggs	Average percentage hatch of hens in each class	Number hens	Range in average percentage of fertile eggs	Average percentage hatch of hens in each class
	Percentage(a) fertile	Percentage(a) hatched		Percentage(a) fertile	Percentage(a) hatched
12	9-40	93	26	81-85	86
7	41-45	86	43	86-90	90
5	46-50	81	38	91-95	87
6	51-55	85	93	96-100	89
10	56-60	94			
10	61-65	81	Totals 299		
15	66-70	80			
12	71-75	88	Ave. per hen	83	87
22	76-80	85			

(a) To nearest whole number.

was close agreement between fertility rate and hatching rate. Additional evidence of fluctuation and unreliability of fertility as an index is indicated by some of the negative extremes. In one case, the fertility rate of a hen was only 9 percent but the hatching rate of fertile eggs from the same hen was 89 percent. In another case, the fertility rate was 100 percent but only 41 percent of the eggs hatched.

It may be concluded that fertility rate is not a reliable index of hatching power and therefore selection for improving hatchability by breeding should be based on the hatchability rate of fertile eggs of individually pedigreed hens.

(2-CHLOROETHYL)-TRIMETHYLAMMONIUM CHLORIDE AND RELATED COMPOUNDS AS PLANT GROWTH SUBSTANCES.

IV. EFFECT ON CHRYSANTHEMUMS AND POINSETTIAS

By R. S. LINDSTROM and N. E. TOLBERT

DEPARTMENT OF HORTICULTURE AND AGRICULTURAL CHEMISTRY

CHEMICAL CONTROL OF VEGETATIVE GROWTH without injury to plants would be a great asset in the production and marketing of many flower crops. The compound, (2-chloroethyl)trimethylammonium chloride, or CCC, has induced some plants to produce shorter and thicker stems and thicker leaves (Tolbert, 1960 a, b, c). Thus, this substance, or a derivative of it, might have practical applications in floriculture. Two major floricultural crops, for which a shorter plant would be preferred over present varieties, are chrysanthemums and poinsettias. This paper reports that a substantial reduction in height can be achieved by using these chemicals, without greatly affecting the number of days to flowering.

MATERIALS AND METHODS

The chemicals were synthesized as previously described (Tolbert, 1960a). Some of them are available now for research investigation from the American Cyanamid Company, Stamford, Connecticut. The following compounds were used: (2-chloroethyl)trimethylammonium chloride, or CCC, (2-bromoethyl)trimethylammonium bromide, or BCB, allyltrimethylammonium bromide, or AMAB, and (2-chloroally)-trimethylammonium chloride, or CAC. These were selected as the most active substances on the basis of previous testing of a large number of homologous compounds (Tolbert, 1960a).

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Since the compounds were infinitely water soluble, they were applied in aqueous solutions. Plants were treated by one of three methods: (1) as a soil drench of 100 ml. of solution poured on top of the soil of 4-inch pots or 150 ml. for 6-inch pots; (2) as a spray with a wetting agent of 0.01 percent aerosol OT applied to the foliage until the leaves were completely wet; (3) as a solid by mixing the compounds with the soil at the time of potting. The molarity of the solutions used is given in tables and figures. In all cases, there were five plants per treatment which were in separate pots.

Rooted cuttings of chrysanthemum plants (*Chrysanthemum morifolium*, var. Indianapolis Yellow) and poinsettia (*Euphorbia pulcherrima*, var. Barbara Ecke) were obtained from commercial sources. The chrysanthemum cuttings were planted in 4-inch pots and immediately subjected to short photo-periods by artificial shading from 5 p.m. to 8 a.m. Two weeks after the beginning of the short-day treatment, the chemical was first applied.

A second application to some plants was made one month later, when the terminal buds were clearly visible. At the time of the second application, gibberellin also was applied to certain plants as a foliar spray. Dates for these treatments are given in figures and tables. Final measurements of plant height were made from soil level to the base of the calyx of the terminal flower.

RESULTS

The early growth of chrysanthemum plants after different treatments is shown in Fig. 1A. BCB, CCC, and AMAB were all effective when 100 ml. of 10^{-2} M or 5 x 10^{-2} M solution was applied once as a soil drench two weeks after the beginning of short days. The treated plants were very short (Tables 1 and 2), but had the same number of leaves per plant as on untreated control plants. The leaves were larger in size, darker green, and somewhat thicker and stiffer than the controls. It was also observed that the time required to induce wilting was much greater in treated plants than in control plants. CAC caused yellowing of the plants at the 10^{-2} and 5 x 10^{-2} M concentrations which were necessary to produce shorter plants.

When chemicals were applied as a spray of 5 x 10^{-2} M solution, toxic symptoms were observed in the form of light green or chlorotic edges of the leaves. One application of a foliar spray at 10^{-2} M pro-

TABLE 1—The effect of AMAB, BCB and Gibberellin on height and number of days to flowering of chrysanthemum. Plants were potted October 8 and treated October 23. Part of the plants received a second treatment November 23, or one month later. Gibberellin was applied to some plants as a foliar spray (500 p.p.m.) November 24

Chemical	Method of application	Concentration (Molar)	Number of applications	Gibberellin	Height (cm)	Days to flower
Control			—	0	39.8	58.2
AMAB	Foliar	10^{-2}	1	0	38.5	59.6
	Spray	5×10^{-2}	1	0	33.6	63.6
BCB	Foliar	10^{-2}	1	0	37.6	58.6
	Spray	5×10^{-2}	1	0	37.0	62.2
AMAB	Soil Drench	10^{-2}	1	0	28.0	59.8
		10^{-2}	2	0	23.8	61.2
		10^{-2}	1	+	31.4	59.8
		10^{-2}	2	+	32.6	61.6
		5×10^{-2}	1	0	18.4	67.4
		5×10^{-2}	2	0	15.8	67.6
		5×10^{-2}	1	+	28.4	64.8
		5×10^{-2}	2	+	25.8	64.6
BCB	Soil Drench	10^{-2}	1	0	32.5	58.2
		10^{-2}	2	0	32.0	58.6
		10^{-2}	1	+	36.6	58.6
		10^{-2}	2	+	38.6	59.8
		5×10^{-2}	1	0	24.6	64.6
		5×10^{-2}	2	0	18.8	66.2
		5×10^{-2}	1	+	32.0	63.8
		5×10^{-2}	2	+	32.4	63.4
L.S.D. 1 percent					3.62	2.74
5 percent					2.74	2.07

duced no toxicity but resulted in less response than one application of the soil drench. Therefore, foliar spray of chrysanthemums was discontinued.

Later development and flowering of treated plants are shown in Figures 1B, 1C and 1D. Measurements of final height after flowering are given in Tables 1 and 2 for two different experiments. Most were of plants treated with AMAB, but similar results were obtained with BCB and CCC. In order to further reduce the growth of the main axis, a second application of the chemicals was made to some plants when the terminal buds were approximately ¼ inch in diameter (Fig. 1A). In

TABLE 2—Effect of CCC, AMAB and Gibberellin on the height and weight of chrysanthemums. Plants were potted December 23 and treated January 18 by the soil drench method. Part of the plants received a second treatment February 19 as well as gibberellin (500 p.p.m.) if applicable

Chemical	Concentration (Molar)	Number of applications	Gibberellin	Height (cm.)	Dry weight (gm.)	Fresh weight (gm.)
Control	.....	—	—	43.0	19.6	165.6
CCC	10^{-2}	1	0	37.2	18.6	153.0
	10^{-2}	2	0	37.8	18.6	153.6
	10^{-2}	2	+	33.0	15.5	148.0
	5×10^{-2}	1	0	29.4	16.8	152.6
	5×10^{-2}	2	0	32.4	17.5	158.2
	5×10^{-2}	2	+	26.8	15.1	152.2
AMAB	10^{-2}	1	0	31.0	16.1	147.6
	10^{-2}	2	0	37.4	18.2	156.0
	10^{-2}	2	+	38.4	18.7	155.0
	5×10^{-2}	1	0	27.2	15.3	136.8
	5×10^{-2}	2	0	25.8	13.5	124.2
	5×10^{-2}	2	+	24.8	13.1	108.6
CAC	10^{-2}	1	0	26.4	11.1	100.8
	10^{-2}	2	0	27.4	12.3	111.6
	10^{-2}	2	+	30.4	11.7	108.4
L.S.D. 5 percent	.....	.....	.....	3.30	2.11	18.62
1 percent	.....	.....	.....	4.37	2.80	24.67

Fig. 1. Effect of BCB and AMAB on the growth of Chrysanthemums. All plants were propagated and first treated on October 23 with BCB and AMAB by the soil drench procedure. A spray application of gibberellin and a second treatment of BCB or AMAB, also by soil drench, were given to specified plants one month later when the flower buds were first visible. Treatments are described from left to right.

A. Photographed November 24: control, 5×10^{-2} M AMAB, 5×10^{-2}, BCB.

B. Photographed December 7: control, 5×10^{-2} M BCB, two applications of 5×10^{-2} M BCB.

C. Photographed December 29: control, 10^{-2} M AMAB, two applications of 10^{-2} M AMAB, 10^{-2} M AMAB plus gibberellin, two applications of 10^{-2} M AMAB plus gibberellin.

D. Photographed December 29: control, 5×10^{-2} M AMAB, two applications of 5×10^{-2} M AMAB, 5×10^{-2} M AMAB plus gibberellin, two applications of 5×10^{-2} M AMAB plus gibberellin.

A
B
C
D

final appearance the treated chrysanthemums were much shorter in height, but there was not a great reduction in total fresh or dry weight of the plant (Table 2). Plants treated with 5 x 10^{-2} M solutions were of excellent quality but very short. Using one or two soil applications of 100 ml. of 10^{-2} M BCB, AMAB or CCC resulted in plants with the best final appearance. Application of a dilute gibberellin spray of 100 p.p.m. before the later development of the flowers produced a more satisfactory floral inflorescence. Plants treated with 10^{-2} M solutions flowered at approximately the same time as the controls (Table 1). Even for the 5 x 10^{-2} M treatments, flowering was only delayed 7 to 10 days.

At the time of the second application of the chemicals, some plants also were sprayed with 500 or 100 p.p.m. gibberellin. Elongation of the main axis at this time was nearly complete. Thus, gibberellin treatment resulted in rapid elongation of only the terminal axis and the flower peduncles (Fig. 1C and 1D).

The long peduncles from application of 500 p.p.m. of gibberellin were particularly noticeable for plants which had had 5 x 10^{-2} M AMAB because of the very short axis of these plants. Since the main axis of plants treated at 10^{-2} M was longer, a better floral spray resulted after gibberellin treatment. In later experiments with 100 p.p.m. of gibberellin, a better flower spray formation was obtained. It also was observed from using gibberellin at this particular stage of plant development that the "clubby" floral inflorescences, which are frequently seen in the winter on many chrysanthemum varieties, could be eliminated.

The keeping quality of plants after flowering was greatly increased by treatment with CCC, BCB and AMAB. It should also be mentioned that treated plants did not wilt as fast as did the control plants. These two aspects are probably related, and further investigation of these observations should be conducted.

Poinsettia plants were propagated and treated as described with Fig. 2A and 2B. Shorter plants were obtained when BCB and AMAB were applied as a soil drench by 100 ml. of 10^{-2} M solution to 4-inch pots (Fig. 2A). Earlier experiments had indicated that treatment with 10^{-3} M solutions were ineffective. Application of 10^{-1} M solutions by any method produced severe toxicity symptoms of chlorosis, leaf drop and stunted growth. Mixing with the soil an amount of solid chemical, which was equivalent to that used in the soil drench procedure, was also an effective method of application (Fig. 2B). Pour-

ing a solution of the chemical on the soil was, however, much faster and, therefore, recommended. Spray treatments were less effective and the results are not detailed. It appeared as if it were necessary to spray at least every other week for good results, but the objective was to produce shorter plants with the least amount of time and effort.

Only BCB and AMAB have been tested on poinsettias. Both chemicals were about equally effective in reducing the height of the plants. The average height of plants, which had been treated once with 10^{-2} M AMAB as a soil drench, was 26.7 cm. as compared with 51.6 cm. of growth by untreated plants (Table 3). Plants treated with a similar application of BCB grew 21.5 cm. CCC if tested should have produced similar results. A second soil drench treatment appeared to be of little

TABLE 3—The effect of AMAB and BCB on the elongation of the main axis of poinsettia. Plants were propagated July 28 and treated September 18. Part of the plants received a second application of the chemicals October 23

Chemical	Method of application	Concentration (Molar)	Number of applications	Cm. of growth after treatment
Control		—	—	51.6
AMAB	Solid	10^{-1}	1	8.4
		10^{-2}	1	17.4
		10^{-2}	2	15.6
BCB	Solid	10^{-1}	1	4.8
		10^{-2}	1	17.4
		10^{-2}	2	19.2
AMAB	Soil Drench	10^{-1}	1	11.2
		10^{-2}	1	26.7
		10^{-2}	2	34.8
BCB	Soil Drench	10^{-1}	1	8.3
		10^{-2}	1	21.5
		10^{-2}	2	22.3
AMAB	Spray	10^{-1}	1	34.9
		10^{-2}	2	41.5
BCB	Spray	10^{-1}	1	22.3
		10^{-2}	1	34.8
		10^{-2}	2	32.3
L.S.D. 1 percent				5.37
5 percent				4.10

or no additional value. Bracts on plants treated with 10^{-2} M solutions by soil drench were as large as those on untreated plants and there was no difference in pigmentation in these bracts. Bract formation developed at a slower rate in the control plants, but this rate was not carefully measured. Further investigations will be needed to establish any decrease in the time of bract development from the use of these chemicals.

Poinsettias from an early propagation on July 8 also were treated with BCB and AMAB as described in Fig. 2C. Such early propagation is not often considered a recommended practice because of the rank growth which is obtained before flower initiation (Fig. 2C). Summer propagation would be, however, a desirable practice in order to obtain sufficient cuttings from limited propagating stock. In this experiment the chemicals resulted in a reduction of the final height from 95 cm. in the controls to about 69 to 76 cm. for treated plants. The compounds were more effective during the growth of the lower internodes, as can be observed in Fig. 2C.

To measure this early effect, the stem was divided into an equal number of upper and lower internodes and the average distance between internodes of each group was measured. The average length for the lower half of the internodes was reduced from 2.52 cm. on untreated plants to 1.85 cm. on plants treated with BCB. However, the average length of the upper internodes was 4.62 cm. on untreated plants and was reduced to only 4.21 cm. with BCB. A second application of the chemical did not prevent much of the latter growth in height and there are two possible explanations for this lack of effect. Since the chemical was applied before repotting into a 6-inch pot, roots that grew into the new soil mixture may not have been exposed to additional chemicals.

Fig. 2. Effect of BCB and AMAB on growth of Poinsettia.

Treatments are described from left to right.

A. Control, 10^{-2} M BCB, 10^{-1} M BCB; propagated July 28, treated by soil drench September 18 and photographed December 7.

B. Control, 0.25 gm. BCB mixed into the soil, 2.5 gm. BCB mixed into soil, 10^{-2} M BCB by foliar spray; propagated July 28, treated September 18 and photographed December 7.

C. Control, 10^{-2} M AMAB, two applications 10^{-2} M AMAB, 10^{-2} M BCB, two applications of 10^{-2} BCB; propagated July 8, treated first August 18 and some plants a second time September 9 and photographed November 24.

A
B
C

Also, since gibberellin has been shown to reverse the effect of these chemicals (2, 3) (see results with chrysanthemums), it may be postulated that the accumulation of natural occurring gibberellin during later growth of the poinsettias negated the effects of BCB and AMAB. When BCB or AMAB were applied to poinsettia cuttings from later propagations in the fall, bract formation occurred before sufficient gibberellin could accumulate to reverse the effect of the chemicals.

DISCUSSION

Only those derivatives of (2-chloroethyl)trimethylammonium chloride have been tested on chrysanthemums and poinsettias which were found to be most active in the original screening program with wheat and squash (Tolbert, 1960c). It has been observed that the most active derivatives on wheat and squash also have been most effective on other plants which have been tested. Therefore, we have assumed that other derivatives so far synthesized, which were less effective on wheat and squash, would also be less effective on chrysanthemums and poinsettias.

That this assumption may be partially incorrect is suggested by results with (2-chloroallyl) trimethylammonium chloride, or CAC. Although CAC has been very active on wheat (Tolbert, 1960c), grasses,[1] cucurbits,[2] beans,[3] and tomatoes (Wittwer and Tolbert, 1960), and lilies,[4] it had adverse toxicity effects on chrysanthemums at concentrations which were necessary to produce a shorter plant.

Whereas BCB, CCC and AMAB were effective when 10^{-3} to 10^{-6} M solutions were poured on the soil to alter the growth of wheat, tomatoes and cucurbits, they were effective on chrysanthemums and poinsettias only at 10^{-2} M. From experience on testing various plants, it appeared that there was a group of otherwise unrelated species of plants which were affected by 10^{-3} to 10^{-5} M solutions of the chemicals, and another group, including chrysanthemums and poinsettias, which required 10^{-2} M solutions. Therefore, investigations are still in progress to determine and synthesize still more active structures for the latter types of plants.

One application of 100 ml. of 10^{-2} M solution of these compounds to the soil of a 4-inch pot approached a dangerous level of excess salt

[1] S. H. Wittwer and N. E. Tolbert, unpublished.
[2] W. D. Mitchell, S. H. Wittwer and N. E. Tolbert, unpublished.
[3] S. H. Wittwer and N. E. Tolbert, unpublished.
[4] R. S. Lindstrom and N. E. Tolbert, unpublished.

for plant growth. Solutions of 5×10^{-2} M were the highest concentration which could be used without a salt effect and even then, good drainage of the pots and sufficient watering should be carried out during subsequent growth.

Preliminary toxicity studies of the chemicals by American Cyanamid Company has indicated that acute toxicity to rats was 1.34 gm./kg body weight for AMAB and 0.67 gm./kg. for CCC. Thirty-day toxicity tests revealed no toxicity symptoms when fed at the rate of 0.227 gm. of CCC/kg. per day. The results suggest that these chemicals may be sufficiently non-toxic so that their application to non-food plants, such as chrysanthemums and poinsettias, will not be judged dangerous. On the other hand, re-use of pots after a 5×10^{-2} M application of the chemical might result in altered growth of some other plant more sensitive to the chemical. This can be easily avoided by segregation of pots or by a thorough washing which removes the very water soluble chemical from the pot.

Early application of the chemicals to plants, right after the roots have been established, is very desirable in order to reduce the distance between the lower internodes of the plant and to produce a bushy growth for the bottom part of the plant. Preliminary studies with C^{14} — labeled BCB indicated that it was metabolized in plants very slowly if at all.[5] This fact may account for the reason only one early application was necessary to obtain a nearly maximum effect during the life of the plant. It is possible that treatment of the propagating plant with BCB or AMAB a few weeks prior to taking cuttings would result in very short cuttings and even shorter plants than the ones described in this paper. In the present investigation, the cuttings were not treated until they had been well established in pots by which time they were half as tall as the final treated plant at the time of flowering.

Reversal of these effects by gibberellin is of considerable theoretical and practical interest. The hypothetical accumulation of gibberellin in poinsettias could explain why the effect of BCB wears off during later growth and cannot be renewed by further application. Also, the use of gibberellin to produce elongation of peduncles and a large flower cluster on chrysanthemums was effective because the gibberellin negated the effect of BCB and AMAB during flowering.

The action of BCB and AMAB on the development of chrysanthemums and poinsettias appears similar to that obtained by AMO 1618

[5] N. E. Tolbert, unpublished.

or its derivatives (Cathey, 1958). The advantages of BCB and AMAB at this time appear to be primarily those of availability and cost as well as ease of application.

SUMMARY

The action of (2-chloroethyl)trimethylammonium chloride (CCC), (2-bromoethyl)trimethylammonium bromide (BCB) and allyltrimethylammonium bromide (AMAB) was tested on growth and flowering of chrysanthemum and poinsettia. The chemicals were most effective when applied as a soil drench or mixed directly with the soil. All chemicals were effective when 100 ml. of 10^{-2} M solution were poured on the soil of a 4-inch pot. A 5×10^{-2} M solution produced more severe effects. The most characteristic growth alteration was the development of very short plants with thick stems.

The number of leaves was not altered nor was there a substantial change in the number of days to flowering. Chrysanthemum leaves were darker green and thicker than on untreated plants. The weight of treated plants was not severely reduced by these treatments. Less wilting during growth and improved keeping quality of the plants after flowering was observed. Application of gibberellin prior to flowering of treated chrysanthemums produced a more satisfactory floral inflorescense.

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THE EFFECT OF METHODS OF FREEZING APPLE SLICES ON CONSUMER PREFERENCE FOR PIES

By W. SMITH GREIG,[1] MARY E. GRANT,[2] and HENRY E. LARZELERE[1]

INTRODUCTION

UNTIL THE RECENT DEVELOPMENT of dehydrofreezing, (Talburt et al. 1950), there were three principal methods of freezing apple slices. These methods differed in the pre-freezing treatment for enzyme inactivation and prevention of browning. The processes were: (1) a steam or hot water blanch, (2) a sodium bisulfite dip, and (3) a vacuum process in which air is removed from the apple slices and replaced with liquid, (Smock and Neubert, 1950). Many commercial apple processors may use two of these methods or all three, depending on preferences of individual customers.

Dehydrofreezing is a new process which appears to be particularly adapted to processing apple slices for bakery or institutional use. Apple slices, after a sodium bisulfite dip, are readily dehydrated to 50 percent of their original weight and volume and then are frozen. Substantial savings in freezing, packaging, storing, and transportation costs more than offset the additional costs for dehydration for many commercial processors. Kaufman (1951) estimated savings of nearly 30 percent in cost of manufacture and long distance shipment of dehydrofrozen, compared with normally frozen apple slices. Current delivered price quotations from the only commercial apple dehydrofreezer indicate considerable savings over normally frozen slices.

While technical aspects and some engineering projections of cost of manufacture and transportation have been reported, no empirical studies have been conducted on product quality.

As quality is particularly important in a new product, tests were

[1]Associate Professors, agricultural economics department, Mich. State. Univ.
[2]Graduate student, home economics department, Wayne State Univ., Detroit, Mich.

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conducted to compare quality of pies made from dehydrofrozen apple slices with pies from apple slices frozen by the three current methods of freezing.

METHODS

Frozen apple slices from similar lots of Northern Spy apples were prepared by the four freezing methods by a commercial processor in November, 1958. Each freezing method — dehydrofreezing, vacuum, sulfur dip, and hot water blanch — was prepared within the same plant on separate commercially used processing lines. The only difference in processing techniques was in pre-freezing treatments. The methods of handling prior to and after the pre-freezing treatments were nearly identical.

Dehydrofrozen samples were dehydrated to 50 percent their original weight and volume and packaged in 15-pound units in a polyethylene bag and cardboard carton. No sugar was added to the apple slices in the process. The hot water blanch, sulfur dip, and vacuum processed apples were packed with a ratio of 7 pounds of fruit to 1 pound of sugar in 30-pound cans.

The same handling methods were used in freezing, storing, and transporting the samples prior to the time pies were to be prepared.

Pies were prepared from the sample lots of frozen apple slices under controlled conditions in a test kitchen. The dehydrofrozen samples (15 pounds) were reconstituted with 15 pounds of hot water. Sugar was added to the dehydrofrozen samples to obtain the same ratio of sugar to fruit as in other sample lots. The volume of pie filling from a 15-pound sample of dehydrofrozen was slightly higher than that from a 30-pound sample of the regularly frozen samples. The same recipe was used on all test lots. The pies were baked, wrapped in aluminum foil, frozen and stored until consumer preference panel tests were to be conducted.[3]

Consumer preference tests were conducted among the samples of apple pies through the M.S.U. Consumer Panel in Detroit, Mich. The selection and composition of consumers for this panel have been described previously, (Larzelere and Gibb, 1956; Greig and Larzelere, 1957). Basically, a large number of consumers was chosen by a random sampling of listings in the Detroit telephone directory; individuals

[3]A detailed report of test cooking methodologies and consumer preference testing will be presented to the Graduate School of Wayne State Univ. by Miss Grant as partial requirement for an advanced degree in Home Economics.

selected were classified by age, income, sex, and education. A subsample of these consumers was then chosen for a special panel test. In each test, consumers were asked to rank coded samples of products. The panel had previously tested such items as poultry, eggs, potatoes, dehydrated potatoes, fresh apples, pork chops, and ice cream.

Test 1

In the first test, consumers ranked coded samples of each type of apple pie according to preference from 1, highest, to 4, lowest (Fig. 1). This method had been used previously on other products by most panel members. The frozen pies were thawed at room temperature and given a short bake to "freshen" the pastry before being served. Each consumer was served a sample of approximately 1/12 of a 9-inch pie made from slices produced by each of the four processing methods. Since the serving plates were circular, an equal opportunity for testing any particular sample first was afforded each consumer.

Fig. 1. Consumer samples of apple pies made from apple slices prepared by four freezing methods: dehydrofreezing, vacuum process, sulfur dip and hot water blanch.

Of the 117 consumers sampling, pies from dehydrofrozen apple slices were ranked first by the greatest number. This process was ranked highest 45 times, vacuum process 29 times, sulfur dip 24 times, while the hot water blanch ranked highest only 19 times. (Table 1).

A statistical analysis of results, Kendall (1955), indicated a highly significant agreement among consumers that there was a difference in preference for the pies. Pies prepared from dehydrofrozen apple slices were highly significantly preferred over pies from hot water blanch and sulfur dip processed apple slices. Similarly, the dehydrofreezing was significantly preferred over the vacuum process. There were no significant preferences among any other comparisons. (Table 2).

TABLE 1—Consumer panel preference rankings of apple pies made from slices prepared by four freezing methods, by 117 consumers, April, 1959

Freezing method**	Number of times ranked				
	First	Second	Third	Fourth	Total
Dehydrofrozen	45	25	31	16	117
Vacuum process	29	31	28	29	117
Sulfur dip	24	30	28	35	117
Hot water blanch	19	31	32	35	117

**Significant differences in ranking at the 1 percent level. The odds are 99 to 1 that these differences in ranking were not due to chance alone.

Test 2

As pies from the vacuum processed frozen apple slices were ranked closest to those from dehydrofrozen slices, the second test was a "triangle" one between sample pies made from apple slices prepared by these two methods. With the "triangle" test method, each panel member was given three samples, two of which were identical and one "different". The consumer was asked to pick out the "different" sample.

Of the 126 consumers testing dehydrofrozen and vacuum process pies in the triangle test, 77 were able to correctly identify the "different" sample. (Table 2). This indicates definite differences between pies made from the two processes and a highly significant number of consumers could choose these differences (Roessler, 1956).

Of 77 consumers who were able to "pick out" the "different" sample from the three choices, 41 preferred the dehydrofrozen and 36 the

TABLE 2—Triangle test of apple pies made from dehydrofrozen and vacuum process frozen apple slices, 126 consumers, May 1959

Total consumers participating	126	
Could not differentiate between products	49	
Correctly differentiated between products	77**	
Preference for dehydrofrozen		41
Preference for vacuum process		36
Total correctly differentiating products		77

**Consumer discernment of differences significant at the 1 percent level.

vacuum process pies. This difference in preference was not significant and could have been due to chance alone.

Test 3

The rank test method of comparing pies from all four freezing methods was repeated after a two-month lapse of time. Methods employed were the same as those in the first test.

As in the first rank test, dehydrofrozen samples were rated highest. Forty-three consumers ranked dehydrofrozen highest, 27 ranked vacuum process highest, 28 sulfur dip, and only 16 ranked pies from the hot water blanch best. (Table 3) Consumers again significantly agreed that there was a difference in the pies. In individual comparisons, dehydrofrozen was again highly significantly preferred over the hot water blanch process. (Table 4) No other individual comparison of the pies from the four processing methods was significant; the higher ranking could have been due somewhat to chance alone.

In analyzing the two rank tests combined, the dehydrofrozen pies

TABLE 3—Consumer preference rankings of pies made from apple slices prepared by four freezing methods, 112 consumers, June 1959

Freezing method*	Number of times ranked				
	First	Second	Third	Fourth	Total
Dehydrofrozen	43	22	26	21	112
Vacuum process	27	21	28	36	112
Sulfur dip	28	33	30	21	112
Hot water blanch	16	37	28	31	112

*Significant differences in ranking at the 5 percent level. The odds are over 19 to 1 that these differences in rankings were not due to chance alone.

TABLE 4—Individual comparisons of consumer preferences between pies made from different processing methods, individual results and combined results of two rank tests, Detroit, Michigan, 1959

Processing method	Chi square values		
	Rank test No. 1	Rank test No. 2	Combined rank tests
Dehydrofrozen vs. hot water blanch....	18.2918**	18.1104**	34.9149**
Dehydrofrozen vs. sulfur dip.....	14.0768**	5.65546	15.4744**
Dehydrofrozen vs. vacuum process.....	7.8732*	7.7014	15.0188**
Vacuum process vs. sulfur dip.....	1.0456	6.6006	1.9418
Vacuum process vs. hot water blanch...	2.9124	7.6006	7.1222
Sulfur dip vs. hot water blanch.....	5.4934	5.4934	4.1922

**Significant at the 1 percent level.
*Significant at the 5 percent level.

were highly significantly preferred over each of the other three processes. There was no significant preference among pies from the vacuum process, the sulfur dip process, and hot water blanch process.

SUMMARY AND CONCLUSIONS

In two consumer preference rank tests of pies made from dehydrofrozen apple slices compared with pies from frozen apple slices prepared by three other current methods of freezing, dehydrofrozen pies were rated highest in both tests.

Consumer agreement in ranking in both tests indicated a highly significant preference for dehydrofrozen slices over pies made from hot water blanch processed frozen apple slices. In one rank test, dehydrofrozen was highly significantly preferred over the sulfur dip and significantly preferred over the vacuum process.

A combination of the two rank tests gives a highly significant preference for dehydrofrozen over each of the other three processes, and no significant preference for any comparisons among the vacuum, sulfur dip, and the hot water blanch processes.

In a triangle test, comparing pies from dehydrofrozen and vacuum processed frozen apple slices, there was a significant discernment of differences, but a nonsignificant preference.

Engineering projections of cost of production and transportation have indicated considerable savings in dehydrofreezing over other methods. Current price quotations of a commercial producer bear out these projections.

The consumer preference data indicate that under controlled conditions of reconstitution and baking, pies made from dehydrofrozen apple slices are equal or superior to those made from slices prepared by the current normally used freezing procedures.

Institutional acceptance tests of dehydrofrozen and dehydrocanned apple slices are currently being conducted.

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JOURNAL ARTICLE ABSTRACTS

The Place and Contribution of Grasslands to the Agriculture of the Corn Belt

TESAR, MILO B.

Grasslands, Am. Assoc. for the Advancement of Sci., pp. 61-73. 1959. (Journal Article 2080 from the Michigan Agricultural Experiment Station)

Legumes and grasses are an integral part of the agriculture of the Corn Belt states of Iowa, Illinois, Indiana, Ohio, Minnesota, Wisconsin, and Michigan. The increased importance of grasslands to the agriculture of these and the dairy states in the last two decades may be attributed to scientific advances which have been reflected in more profitable farming. These advances include the introduction of new species and the use of superior new varieties of alfalfa, Ladino clover, and bromegrass. Increased knowledge of the requirements of P and K by forages and their proper establishment and management has been reflected in higher yields of forages of higher quality and longer life. Future scientific advances in breeding and management should be manifested in maintaining – or increasing – the importance of forages in farm rotations in this rich agricultural area.

Implications of Calculated Economic Optima in the Cauca Valley, Colombia, S.A.

TRANT, G. I.

Jour. of Farm Econ. 40:123-133. 1958. (Journal Article 2197 from the Michigan Agricultural Experiment Station)

Agricultural production in Colombia must be increased if the present high rates of population growth and industrial developments are to be supported adequately. Some of this increased production can be obtained from the development of new land. However, the largest portion will have to come from a more efficient use of the land resources already in production. Powerful institutional factors limit the amount of available farm land that may be used for crop growing. Thus, improved land use efficiency in crop production is of vital importance to Colombia.

Since the current agricultural resource combinations are widely out of economic adjustment, changes which improve these combinations are highly productive. One way of making such adjustments has been demonstrated in this paper with the fertilizer experiments for corn and sugar cane. Obviously these experiments provide only partial solutions to the problem of increased crop production.

The corn experiments and associated field demonstrations indicate that the goal of a 28-percent increase in Colombian corn production can be met fairly readily and cheaply by the application of nitrogen fertilizer. The sugar-cane fertilizer response experiments have served as a basis for a decision not to fertilize newly planted sugar cane at one large plantation. The forthcoming results of the experiment in older cane will be used in deciding whether or not to fertilize sugar cane of that age. Both sets of experiments have indicated the direction in which further investigational work with fertilizer may be profitably carried out in the two crops.

More work of a similar nature is needed in Colombia, particularly with the other important crops: rice, beans, plantain, coffee and cotton.

When more Colombian farmers are made aware of the nature of these factor-product relationships and decide to take action based upon them, the importance of institutions as the limiting factor to increased productivity in Colombian agriculture may be more apparent than real.

Effect of Nitrogen on Yield and Subsequent Germinability of Sugar Beet Seed

SNYDER, F. W.

Jour. of the Am. Soc. of Sugar Beet Tech. 10: 439-443. 1959. (Journal Article 2199 from the Michigan Agricultural Experiment Station)

Sugar beet plants were grown outdoors in crocks containing vermiculite. They were supplied with adequate versus excessive quantities of nitrogen as ammonium nitrate. Seed was harvested by individual plants and tested for speed and percentage of germination by the liquid-contact method. Essentially no difference was noted in the speed and percentage germination. Clones and varieties reacted differently to an excess of nitrogen in the nutrient solution. Some plants were injured by the excess nitrogen.

The Effect of Fertilizers on Sugar Beets Including an Economic Optima Study of the Response

DAVIS, J. F.; W. B. SUNDQUIST AND M. G. FRAKES

Jour. of the Am. Soc. of Sugar Beet Tech. 10:424-434. 1959. (Journal Article 2212 from the Michigan Agricultural Experiment Station)

The effect of seven phosphate levels (60, 100, 150, 225, 300, 500 and 800 pounds of P_2O_5 per acre) and five potash levels (30, 75, 150, 250 and 400 pounds of K_2O per acre) applied to a Parkhill clay loam on the yield, sucrose content and purity of sugar beets was determined. The petioles were analyzed for phosphorus and potassium at three dates (July 14, August 4, and August 28). The effect of different extractants on the phosphorus and potassium extracted from the soil was investigated. In addition, an economic analysis of the yield data was made to estimate optimum nutrient combinations with current sugar beet and fertilizer prices.

50 - 100 pounds of P_2O_5 and 250 pounds of K_2O were the most profitable applications. Potassium increased sucrose content of roots by 0.5 percent. P and K contents of petioles were erratic and varied markedly with date of sampling with a tendency for the K content to be affected by the amount of phosphate applied.

Effect of Gibberellin on Germination and Early Growth of the Sugar Beet

SNYDER, F. W.

Jour. of the Am. Soc. of Sugar Beet Tech. 10: 394-395. 1959. (Journal Article 2227 from the Michigan Agricultural Experiment Station)

Soaking either seedballs or seeds in gibberellin solutions as concentrated as 10,000 p.p.m. did not hasten germination. The higher concentrations did stimulate stem elongation. A dust formulation at twice the rate recommended by the formulator was ineffective.

Economics of Various Methods of Harvesting and Utilizing Forages

HOGLUND, C. R.

Jour. of Dairy Sci. 42:1101-1108. 1959. (Journal Article 2260 from the Michigan Agricultural Experiment Station)

The most profitable combination of forage harvesting and feeding methods to be used on an individual farm depends on the size and intensity of the livestock enterprise, labor supply, available buildings, feed storage facilities, equipment and capital, the quantity and quality of feed nutrients preserved, and on other factors. The most profitable allocation of $5,000 to a dairy farm with 27 cows, some potential barn space and labor to care for at least five more cows, would be to purchase the five cows and invest the balance in a hay conditioner and more silage capacity. Net income would be increased the least when the entire $5,000 was invested in a chopper, blower, wagons and a silo.

Dormancy and Germination Characteristics of the Seeds of Sheep Sorrel, *Rumex Acetosella L*

STEINBAUER, G. P. AND BUFORD GRIGSBY

Proc. Assoc. Off. Seed Anal. 48:118-120. 1958. (Journal Article 2280 from the Michigan Agricultural Experiment Station)

1. Various combinations of environmental factors were tested for promotion of germination of sheep sorrel seeds.

2. Maximum germination was obtained when the seeds were exposed to a 8- to 20-hour photoperiod, using 0.2 percent nitrate solution as a moistening agent. High germinations were obtained at constant 20°C., and constant 30°C., with highest values at the daily alternation of 20°C. - 30°C.

3. Optimum conditions for germination change but little with age except that the need for nitrate solution diminishes somewhat with time.

4. The speed of germination varies greatly. Fresh seeds may require three or four weeks for complete germination. The time required for the test may be seven or eight days for seeds held in dry storage for four months after harvest.

5. Seeds of sheep sorrel may remain viable for several years in dry storage although limited data indicate a rapid decline in viability after about two years.

A Soil Suction Value Associated with Moisture Levels Adjusted by the Adventitious Root Technic

STOLZY, L. H. AND A. E. ERICKSON

Soil Sci. 88:7779. 1959. (Journal Article 2305 from the Michigan Agricultural Experiment Station)

Breazeale and McGeorge indicated that the values obtained by their technic were wilting percentages. The justification for so designating these values was based on a comparison of their moisture value with values determined by the indirect method suggested by Briggs and Shantz, in which the wilting percentage is determined by dividing the moisture equivalent by the factor 1.84. Considerable deviation would be expected between a wilting percentage determined

with sunflowers and a calculated value based on the moisture equivalent, because the factor 1.84 is not a constant for all soils. Also, because the tomato plant did not wilt during these determinations, the present writers would prefer not to call this a wilting percentage; a more realistic term would be "lower turgor pressure percentage." This would mean that a plant in a given atmospheric environment could maintain full turgidity at this moisture percent or at this soil suction value.

With increasing evidence that differential moisture regimes influence growth rates of plants, a suction value other than the permanent wilting percentage should be found to determine irrigation levels. From this study, it would appear that the five-bar soil suction value is the maximum value to use under favorable atmospheric conditions.

Behavior of Starch During Food Preparation II. Effects of Different Sugars on the Viscosity and Gel Strength of Starch Pastes

BEAN, MAURA L. AND ELIZABETH M. OSMAN

Food Res. 24:665-671. 1959. (Journal Article 2312 from the Michigan Agricultural Experiment Station)

The effects of dextrose, fructose, sucrose, maltose, lactose, sorbitol, invert sirup and corn sirups of three different levels of hydrolytic conversion on the hot-paste viscosity curves and gel strength of 5 percent corn starch paste were reported. With all sugars and sirups used, there was a slight increase in the maximum hot-paste viscosity attained during gelatinization with concentrations of sugar up to 10 or 20 percent, but a decrease with higher concentrations. There were small but consistent differences among the effects of the different sugars. At higher concentrations, the disaccharides were more effective in inhibiting gelatinization than were equal concentrations by weight of monosaccharides. Concentrations of 20 percent or higher of all sugars and sirups used caused decided decreases in gel strength of the starch pastes.

The Influence of Level of Irradiation, Temperature and Length of Storage Upon the Level of Certain Chemical Components and Panel Scores for Beef, Pork and Veal

PEARSON, A. M.; L. J. BRATZLER; O. F. BATZER; R. A. SLIWINSKI AND LUCY CHANG

Food Res. 24:633-644. 1959. (Journal Article 2326 from the Michigan Agricultural Experiment Station)

A study was conducted to determine the effect of level of irradiation, length and temperature of post-irradiation storage upon panel acceptability and certain chemical components in beef, pork and veal. The unirradiated samples were preferred, but neither temperature nor length of storage had a measurable effect upon panel scores. Cooking fresh meat did not alter the level of methyl mercaptan, but increased hydrogen sulfide, carbonyl compounds and pH. However, total and reduced glutathione were lowered by cooking. Irradiation resulted in an increase in methyl mercaptan, hydrogen sulfide and carbonyls, but did not alter pH, total or reduced glutathione. Level of irradiation, temperature and length of storage did not appear to influence methyl mercaptan or hydrogen sulfide, but samples stored at the lower temperature contained higher levels of carbonyls, total and reduced glutathione than those stored at the higher temperatures.

Streptomyces Spp. as a Cause of Natural Fungitoxicity in Soils

LOCKWOOD, JOHN L.

Phytopathology 49:327-331. 1959. (Journal Article 2336 from the Michigan Agricultural Experiment Station)

Natural loam or muck soils lysed mycelia of several fungi growing on various agar media. Mycelia in cultures killed by propylene oxide were also lysed by natural soils. Destruction of mycelium was usually nearly complete when soil was in contact with cultures for 7-14 days. Germination of conidia was inhibited on agar media that had been covered with sterilized Cellophane and soil for 2-7 days before application of spores. Germ tubes and mycelia from conidia that germinated on such media were frequently inhibited or lysed. Soil sterilized by steam or propylene oxide was without lytic or inhibitory effects. Sterilized soil inoculated with mycolytic isolates of *Streptomyces* spp. and incubated 5-15 days produced lytic and inhibitory effects on test fungi similar to those produced by natural unsterilized soil. The presence of diffusible toxins in soils was indicated by fungitoxic effects when soils and fungus were separated by agar or Cellophane barriers. Diffusible fungitoxic substances produced by *Streptomyces* spp. are thought to play a role in natural soil fungitoxicity.

Chemical and Environmental Relationships in Flowering of Acorn Squash

HILLYER, I. G. AND S. H. WITTWER

Proc. ASHS 74:558-568. 1959. (Journal Article 2348 from the Michigan Agricultural Experiment Station)

Treatment with maleic hydrazide, temperature, and day length, separately and when interacting, influenced flower production of Acorn squash as measured by date of appearance, node number, and total numbers of staminate and pistillate flowers. Complete suppression of staminate flowers on Acorn squash grown in the greenhouse was obtained by foliar sprays of maleic hydrazide (250 or 350 p.p.m.) applied during the first and repeated at the fourth to fifth leaf stages. In the field, however, 750 to 1000 p.p.m. was needed for comparable results. A significant reduction or complete chemical suppression of staminate flowers, both in the greenhouse and field, was achieved only under growing conditions consisting of short days (13 hours or less) and low (60 degrees F or below) temperatures. Morphological observations revealed that maleic hydrazide suppressed cell differentiation in terminal meristems and the development of pollen grains in the androecia of staminate flower buds.

Estimation of Thyroid Secretion Rates in Dairy Goats and Measurement of I^{131} Uptake and Release with Regard to Age, Pregnancy, Lactation and Season of the Year

FLAMBOE, E. E. AND E. P. REINEKE

Jour. of An. Sci. 18:1135-1148. 1959. (Journal Article 2360 from the Michigan Agricultural Experiment Station)

The substitution method for measuring thyroid secretion rate in individual intact animals was adapted to the dairy goat.

In both young adult and aged goats, thyroid secretion rate was high in fall, winter and spring, but declined to about one-half the winter level during July. Comparisons between different age groups showed a progressive decline in thyroid secretion rate with advancing age. Neither thyroidal I^{131} uptake nor output rate were correlated consistently with thyroid secretion rate.

During lactation both thyroidal I^{131}, uptake and thyroid secretion rate decreased. Within lactating groups, there was a negative correlation between milk yield and thyroid secretion rate and also between milk yield and thyroidal I^{131} uptake. It was shown that the mammary gland has a very marked ability to concentrate iodide from the blood. The data were interpreted to indicate that during lactation the udder competes with the thyroid for iodine, thus creating a functional thyroid deficiency.

Development of a Recording Volumetric Transducer for Studying Effects of Soil Parameters on Compaction

HOVANESIAN, J. D. AND W. F. BUCHELE

Trans. of the ASAE 2:78-81. 1959. (Journal Article 2367 from the Michigan Agricultural Experiment Station)

The relationship between changes in soil mean stress and changes in bulk density were investigated to determine the influence of wheel traffic upon the soil.

Determining changes in mean stress is one method of measuring soil volume strain. Changes in soil volume strain is related to changes in bulk density.

Tests were conducted on tillable soils by applying known mean stress values (by means of hydrostatic pressure) to small samples of soil encased in a rubber bag and observing the accompanying bulk density changes. General mathematical equations were empirically developed. These equations depend on knowledge of initial conditions and parametric constants. When these constants and initial conditions are known, these equations can be used to accurately predict bulk density changes resulting from certain soil load applications.

The instrumentation problem of accurate specific volume measurement at a point in the soil was solved by development of the volumetric strain gage transduces.

Interspecific Hybrid Between *Phaseolus vulgaris* and *P. lunatus*

HONMA, SHIGEMI AND OTTO HEECKT

Jour. of Heredity 50:233-237. 1959. (Journal Article 2371 from the Michigan Agricultural Experiment Station)

Numerous crosses using heterozygous parents of *P. vulgaris* and *P. lunatus* made it possible to obtain 10 hybrid plants. Eight hybrid plants more closely resembled the *P. vulgaris* plants while two others failed to resemble any of the parents and appeared as willow-leaf sterile plants. The fertility of the eight plants ranged from low to normal. Backcrosses of both parents to the hybrid were made with little difficulty. Segregation for leaf type, seed and pod shape were noted in the F_2 and F_3 populations. Variations in the characters suggest a quantitative type of inheritance.

Plow-Plant Equipment Designed for Corn Production

HANSEN, C. M.; L. S. ROBERTSON AND B. H. GRIGSBY

Trans. of the ASAE 2:65-67. 1959. (Journal Article 2373 from the Michigan Agricultural Experiment Station)

Equipment was mounted on a four-wheel tractor to plow, plant, fertilize and apply pre-emergence spray for weeds in one operation. The 1957 trials showed that corn produced with this equipment yielded 10.9 bushels more than corn grown with the method used by farmer-cooperators. In 1958 corn yields produced where this unit was used were compared with yields where two operation minimum tillage methods were used. The corn grown with the experimental equipment yielded the same as the conventional minimum tillage grown corn. Simazin (an herbicide) sprayed on at planting time, gave the best weed control of all of the weed control practices employed.

Fuel and power requirements were obtained for three cultural practices for growing corn: conventional tillage, minimum tillage and plow-plant. Thirty-six and 37 percent less fuel than horsepower hours per acre, respectively, were required when minimum tillage practices were employed instead of conventional tillage. When the plow-plant system is substituted for the conventional tillage method, 51 and 50 percent less fuel than horsepower hours per acre, respectively, are required. Man hours per acre for growing corn by conventional tillage, minimum tillage and plow-plant, respectively, are 2.34, 1.52 and 1.2.

Heterosis in Barley

GRAFIUS, JOHN E.

Agron. Jour. 51:551-554. 1959. (Journal Article 2384 from the Michigan Agricultural Experiment Station)

Heterosis has been discussed on the basis of the geometrical model for yield, where yield is the volume of a retangular parallelepiped with edges S, Y, and Z equal to heads per plant, seeds per head and average seed weight, respectively. The correlation between the edges X, Y and Z in the F_2 was either small or zero and from this it was suggested that there are no genes for yield per se, but only genes for the components of yield. Yield is thus an artifact. If this is true, the F_1 vigor of yield in barley, a self-fertilized, diploid crop, is due to epistasis. Part of this F_1 vigor should then be fixable in a true breeding form.

A fourth component, date of heading or time, was found to exert an influence on X and Y.

It was found possible to predict the F_1 and F_1 values for X, Y and Z.

Physical and Chemical Changes in Bovine Saliva and Rumen Liquid with Different Hay-Grain Rations

EMERY, R. S.; C. K. SMITH; R. M. GRIMES; C. F. HUFFMAN AND C. W. DUNCAN

Jour. of Dairy Sci. 43:76-80. 1960. (Journal Article 2393 from the Michigan Agricultural Experiment Station)

Saliva and rumen liquid samples were collected from two cows that were fed 20, 40, 60, 80, and 100 percent hay rations. The viscosity of saliva (mean 99 cp.) was greater 3 hours after feeding than before feeding and the pH (mean 8.2)

increased as the proportion of hay increased. The ash of saliva (mean 0.73 percent) was greater with the high-grain rations. Total salivary nitrogen was 20.1 mg. percent for the 20 percent hay ration and averaged 14.9 mg. percent for the 40 to 100 percent hay rations. Hexosamines (mean 4.3 mg. percent) were higher on the high-grain rations. The rumen liquid samples were centrifuged at 25,000xG. and the supernatant analyzed. The mean dry matter content was 1.71 percent and the ash content increased and was higher for the cow which tended to bloat than for the one which did not. Hexosamines (mean 3.7 mg. percent) was also greater for the bloaty cow, but tended to increase in both cows with increasing proportions of grain. The total nitrogen of rumen liquid (mean 37.1 mg. percent) was highest on the 20 percent hay rations, was higher after feeding them before, and was higher for the bloaty cow than for the one which did not.

The Use of Press Wheels on a Drill in Establishing Seedings in Wide-Row Corn

TESAR, MILO B.

Agron. Jour. 51:628-629. 1959. (Journal Article 2394 from the Michigan Agricultural Experiment Station)

The lack of machinery to make seedings of forage crops in wide-row corn has been a deterrent to the use of this practice.

In an attempt to utilize existing machines to seed forages and provide compaction of the seed in the soil with a minimum of operations, a set of gang press wheels was towed behind an ordinary grain drill equipped with a band-seeder attachment. Excellent results were obtained in establishing alfalfa in wide-row corn. The seedings obtained by this equipment should encourage experimentalists and farmers to try seedings of legumes in wide-row corn on a larger scale. All equipment used is available commercially for standard drills.

Recirculation-Spray Versus Manual Cleaning of Milk Storage Tanks

JENSEN, J. M.; L. G. HARMON AND T. I. HEDRICK

Jour. of Milk and Food Tech. 22:206-208. 1959. (Journal Article 2398 from the Michigan Agricultural Experiment Station)

Recirculation-spray washing was compared with manual washing of 2,000 gallon raw milk holding tanks, determined by bacterial swab counts of areas located similarly in three separate tanks. The bacterial counts averaged 26 per sq. cm. with manual and 6.3 and 7.0 with spray-recirculation cleaning, using 140°F. detergent solutions, 5.5 and 4.5 using 160°F. solutions. Chlorinated detergent was used for all washing.

A Method for Evaluating Slow-Bolting Celery Lines

HONMA, SHIGEMI

Proc. ASHS 74:506-513. 1959. (Journal Article 2408 from the Michigan Agricultural Experiment Station)

"Cold units," as calculated by a degree hour method, appeared to be more useful than "venier units" in determining amount of cold exposure necessary for sep-

arating bolters from slow-bolters. Although the "venier unit" method gave an accurate measure of cold intensity, it did not lend itself to comparison of data from the natural and artificial low temperature experiments.

Three years of study on the thermo-induction of celery plants to obtain flowering indicated that length, continuity of cold exposure as well as low temperature were important. Increase in the number of bolters was noted with increase in length of low temperature exposure by artificial and natural methods and confirm the work reported by others. The most effective temperatures for the induction of seeding were at 43 and 48 degrees F. for all varieties studied. For the purpose of screening segregating populations of celery for bolting response, the best procedure appears to be at least five weeks of continuous exposure to a temperature of approximately 45 degrees F.

The Parentage of Hybrid Azaleas

PARIS, C. D.

Quart. Bul. Amer. Rhod. Soc. 14:30-36. 1960. (Journal Article 2413 from the Michigan Agricultural Experiment Station)

The history of the genus *Rhododendron* is discussed. Since the eighteenth century, 60 groups of hybrid azaleas have been created. These are listed in tabular form along with the originator name and address, and year of introduction.

As far as is known, only 27 species have been used in the above groups. Table 2 lists these species with the native habitat, year of introduction and color.

Finally, a chart has been drawn to show the species and hybrids that have been used in the various groups of hybrid azaleas.

Dry Vs. Lye-Solution Storage of Milking Machine Rubber Inflations

JENSEN, J. M.

Jour. of Dairy Sci. 42:1726-1730. 1959. (Journal Article 2414 from the Michigan Agricultural Experiment Station)

Field trials were made comparing lye solution with atmospheric storage for milking machine inflations during alternate seven-day use and rest periods. Data were obtained on weight changes and loss of inflations; general observations were made of their appearance.

Natural and Perbunan rubber milking machine inflations were stored dry and in a five percent cold-lye solution during alternate weeks under field conditions for a year to compare their lasting qualities, weight changes, and appearances.

With dry storage, the natural rubber inflations gained an average of 10.4 percent in weight. Similarly stored Perbunan inflations lost weight, averaging 1.73 percent.

When stored in the lye solution, the natural rubber inflations increased in weight, averaging 3.87 percent. Under similar conditions of storage, the Perbunan inflations lost weight, averaging 8.1 percent.

A higher percentage of natural rubber inflations, 71.3 percent as compared with 29 percent, was discarded when the inflations were stored dry rather than in lye solution. Perbunan inflations were equally durable under either condition of storage.

Lye-solution storage favored retention of shape and quality of the natural rubber inflations; whereas, those dry-stored became enlarged and misshapen with use.

Rate of Potassium Release from Fixed and Native Forms

ELLIS, BOYD G. AND M. M. MORTLAND

Soil Sci. Soc. of Am. Proc. 23:451-453. 1959. (Journal Article 2419 from the Michigan Agricultural Experiment Station)

The rate of release of potassium from mixed and native forms was compared utilizing a biotite-vermiculite system. Although x-ray diffraction patterns of oriented aggregates showed little difference between native biotite and weathered biotite containing fixed potassium, there was a marked difference in the rates of potassium release from the two materials. The release from native biotite was maintained at a constant rate, while nearly 50 percent of the potassium was removed; whereas, with the fixed forms, rate of release decreased with time. The relationship between the logarithm of the rate of release and time was linear. The slopes of these curves were directly related to the extent of weathering which the weathered biotite had undergone before being subjected to the fixation reaction. The ease of release of fixed potassium, therefore, appears to be a function of the extent of weathering of the mica. This may be the result of loss of charge in the mineral during weathering.

Relations Between Weight at First Calving and Milk Production During the First Lactation

MILLER, R. H. AND L. D. MCGILLIARD

Jour. of Dairy Sci. 42:1932-1943. 1959. (Journal Article 2421 from the Michigan Agricultural Experiment Station)

Michigan DHIA-IBM records for 4677 Holsteins, 1001 Guernseys, and 501 Jerseys were used to fit constants by least squares for the independent influences of age and weight on production in the first lactation. These effects indicated delaying calving of heifers is not economically advantageous and that heavier heifers have little or no advantage over lighter heifers of similar age.

Intraherd partial regressions were about 75 lb. of milk per month of age and 200 lb. of milk per 100 lb. weight at first calving. Large correlation between herd averages of weight and production contributed significantly to larger partial regressions of milk on weight when herds were ignored.

Genetic correlations between weight and production were of the order of .3. Heritabilities, based on paternal-sister correlations, ranged from .4 to .8 for weight and .3 to .6 for production in the first lactation.

Dairy heifers should be bred as soon as sufficiently large to minimize possible harmful effects on length of productive life. Selection for increased milk production may result in larger size. Correcting production for weight may remove some genetic variation in production.

The Effect of Injected Thiouracil on Body Weight and Hatchability of the Chick Embryo

SINHA, M. D.; R. K. RINGER; T. H. COLEMAN AND H. C. ZINDEL

Poultry Sci. 38:1405-1409. 1959. (Journal Article 2423 from the Michigan Agricultural Experiment Station)

Various levels of thiouracil (0.1 to 5.0 mg.) were injected into eggs containing 48-hour chick embryos to determine the effect on growth rate and length of in-

cubation. The injection of 5.0 mg. of thioracil was lethal. The body weights of embryos from eggs receiving amounts of thiouracil from 0.1 mg. to 2.0 mg. were significantly less than those of the controls throughout the incubation period.

In general, from the seventh through the 11th days of incubation, no consistent significant differences were found between body weights of embryos from eggs receiving the different levels of thiouracil. After the 11th day of incubation, however, significant differences between embryos on different treatments became evident. The injection of thioracil into eggs containing 48-hour embryos prolonged the incubation period.

The Amino Acid Content of Fresh and Stored Shell Eggs. IV. Determination by Means of Microbiological Assay and Chromatography on Sulfonated Polystyrene Resins

EVANS, R. J.; SELMA L. BANDEMER; D. H. BAUER AND J. A. DAVIDSON

Poultry Sci. 38:1934-1937. 1959 (Journal Article 2427 from the Michigan Agricultural Experiment Station)

Two experiments were conducted to determine changes in amino acid content of shell eggs during storage. Eggs were analyzed fresh and after seven to nine and 16 to 18 months of cold storage. Amino acid contents of egg white and yolk proteins were determined on acid hydrolyzates of the protein preparations by microbiological assay and by chromatographic separation on sulfonated polystyrene resin. Slight losses during storage of shell eggs were indicated for each of the eight amino acids studied by microbiological assay. Chromatographic analysis for 17 amino acids indicated increased concentrations of arginine and phenylalanine in both the white and yolk proteins of shell eggs stored for 16 months, but there was no change in the percentages of most of the amino acids in the proteins. The proline content of the white protein and the tyrosine content of the yolk protein decreased during storage of the eggs.

Effect of Heat Treatment on Surviving Cells

KAUFMANN, O. W.; L. G. HARMON; O. C. PAILTHORP AND I. J. PFLUG

Jour. of Bacty. 78:834-838. 1959. (Journal Article 2430 from the Michigan Agricultural Experiment Station)

The growth characteristics of bacterial cells, which survived 76 ± 1° C. for 17 sec. and 82° C. ± 1° C. for 5 ± 1 sec., were compared with unheated controls; particular emphasis was given to the lag phase of growth. The level of survivors was controlled so as to provide an initial cell concentration of *Micrococcus sp.* MS 102 of 2,000 and 20,000 organisms per cc. Heat shock and recovery studies both were carried out in a milk medium. In all trials the heated cells exhibit a longer lag phase of development than the unheated cells when the population levels are the same. With an initial population of 2,000 per ml. the lag phase increased from 22 to 40 hours when the heat treatment was changed from 76° C. ± 1° C. for 16 sec. to 82° C. ± 1° C. for 5 ± sec. At 20,000 per ml. the lag phase only increased from 19 to 25 hours under the above conditions. The latter is considered to be an insignificant change.

The Nutritive Value of Corn and Soybeans as Influenced by Soil Treatment

RUTHERFORD, B. ELAINE AND K. M. PRETTY

Agron. Jour. 52:27-29. 1960. (Journal Article 2431 from the Michigan Agricultural Experiment Station)

Corn and soybeans were grown on an extremely infertile sandy loam soil to which had been applied large amounts of lime, phosphorus, and potassium in a complete 2^3 factorial design. The second year following soil treatments, samples of these grains, supplemented with corn oil and vitamins, were fed to 128 albino rats for a period of seven weeks. Each diet, representing one of the eight soil treatment combinations, was fed to eight rats. The nutritive value of the feed was assessed by weight gain, nitrogen digestibility, and the Ca and P level of the leg bones of the experimental animals.

Bone composition was the only value in which significant differences were found as a result of feeding the various samples. Lime tended to depress P accumulation in the bone resulting in higher Ca:P ratios. Chemical analyses of the feeds indicated that the P content was increased considerably by applying this nutrient; whereas, the content of other major constituents was not appreciably changed by soil treatment.

Experimental Leptospirosis. VII. Re-Exposure of Pregnant Sows in *Leptospira pomona*

MORTER, R. L.; E. V. MORSE AND R. F. LANGHAM

Am. Jour. of Vet. Res. 21:95-98. 1960. (Journal Article 2432 from the Michigan Agricultural Experiment Station)

Five sows had been experimentally infected with *Leptospira pomona*, 10 to 14 months previously. The sows were re-exposed during the last one-half of the gestation period. The immunity produced by the active infection was sufficient to protect the pregnant sows against challenge with a virulent strain of *L. pomona*. Such immune animals should be retained for breeding purposes.

Active inflammatory processes appear to persist in the porcine kidney for 10-14 months after initial infection and 8 to 10 months after leptospiras were demonstrated in the urine.

The Presence of Adenosine Diphosphoribose and Adenosine Triphosphoribose in Acid Extracts of Certain Animal Tissues

FORREST, R. J.; D. R. WILKEN AND R. G. HANSEN

Biochem. Biophys. Acta 37:551-553. 1960. (Journal Article 2433 from the Michigan Agricultural Experiment Station)

Adenosine Diphosphoribose and Adenosine Triphosphoribose has been identified in the acid soluble extracts of salmon liver, chicken liver and rat mammary gland. Adenosine diphosphoribose has also been identified in extracts of rat liver. The identification has been based on the results of spectral data, phosphorus and ribose analysis, and chromatographic behavior.

Evidence is presented to indicate that this nucleotides could have arisen from reduced pyridine nucleotides present in original tissue.

The findings in this communication are discussed briefly in relation to published reports of other investigations dealing with pyridine nucleotides.

Energy of Falling Drops from Medium Pressure Irrigation Sprinkler

SCHLEUSENER, PAUL E. AND E. H. KIDDER

Agr. Engr. 41:100-103. 1960. (Journal Article 2434 from the Michigan Agricultural Experiment Station)

A study was made (1) to measure the size of drops from an irrigation sprinkler, (2) to develop a technique for measuring and (3) to determine the energy imparted by drops from a sprinkler striking a target near the soil surface. A small irrigation sprinkler was selected and operated at two pressures and with two nozzle size combinations. Drop sizes were determined by sieving flour drop pellets through a standard set of sieves. A transducer was constructed whereby the physical displacement of an elastic member was changed into an electrical signal through the use of strain gages. This equipment was used to record the force of the impacting drops from a pass of the sprinkler.

The logarithm of the median drop mass varied linearly with distance from the nozzle.

The logarithm of the energy imparted by drops from a sprinkler striking a target near ground level varied linearly with distance from the nozzle, increasing rapidly with greater distance from the nozzle.

True water application rates based upon the actual time of application were as high as 7.5 inches per hour, ranging from 30 to 90 times as great as the application rate based on total elapsed time.

Study of the *In Vitro* Parasitization of Bovine Cells by *Brucella abortus*

RICHARDSON, MARVIS

Jour. of Bacty. 78:769-777. 1959. (Journal Article 2435 from the Michigan Agricultural Experiment Station)

Normal bovine fixed-tissue cells have been routinely grown *in vitro* as a monolayer on glass. *Brucella abortus* has been shown to invade, and to multiply rapidly within, bovine cells from fetal skin and kidney as well as adult uterine mucosa, testes, spleen, bone marrow, and lung. Similar intracytoplasmic growth patterns were observed in cells from various tissues. It has been found that *B. aborus* Type I multiplied to the same extent in cells from fetal skin and adult uterine mucosa. *B. abortus* Type I and Type II, both CO_2-dependent and CO_2-independent strains, invaded and multiplied within fetal skin cells at approximately the same rate. The number of intracellular brucellae depended, within limits, both on the number of extracellular organisms to which the cells were exposed and on the exposure time. Intracellular growth rates proved independent of these variables, at least during the first 72 hours of intracellular residence.

***Leptospira Pomona* Isolation from Naturally Occurring Canine Infections**

MORTER, R. L.; J. A. RAY AND D. F. CHAPEL

Jour. of the Am. Vet. Med. Assoc. 135:570-571. 1959. (Journal Article 2441 from the Michigan Agricultural Experiment Station)

Six dogs and six cattle on the same farm were found serologically positive for *Leptospira pomona.*

The isolation of *L. pomona* from the urine of two dogs indicates that the dog should be considered a part of the epidemiologic pattern in this disease.

Some Characteristics of the Glyco-machopeptide of Casein—A Product of the Primary Rennin Reaction

BRUNNER, J. R. AND MARVIN P. THOMPSON

Jour. of Dairy Sci. 42:1881-1883. 1959. (Journal Articles 2452 from the Michigan Agricultural Experiment Station)

The "glyco-macropeptide" (GMP) liberated from casein by the action of rennin was characterized electrophoretically and ultracentrifugally, as well as by analyses for nitrogen, carbohydrate, ash, phosphorus, and neuraminic acid. The average molecular weight, calculated from $M_{SD} = \frac{RT_S}{D(1-V_P)}$, was found to be 15,263. The partial specific volume (V) was determined pycnometrically to be 0.68. The GMP contained 11.7 percent N., 5.1 percent hexose, 2.3 percent hexosamine, 6.0 percent ash, 0.63 percent P, and 11.3 percent neuraminic acid.

The Oral Iron Requirement of the Baby Pig

ULLREY, D. E.; E. R. MILLER; O. A. THOMPSON; I. M. ACKERMAN; D. A. SCHMIDT; J. A. HOEFER AND R. W. LUECKE

Jour. of Nutr. 70:187-192. 1960. (Journal Article 2455 from the Michigan Agricultural Experiment Station)

Forty-five baby pigs were fed a synthetic milk diet (25 p.p.m Fe) supplemented with 0, 10, 50, 100 or 200 p.p.m. of ferrous iron ($FeSO_4.7H_2O$). The following observations were made at weekly or biweekly intervals: weight gains, hemoglobin concentration, hematocrit, erythrocyte count, reticulocyte count, leucocyte count, total serum protein, serum protein electrophoretic pattern, serum iron concentration, unbound iron binding capacity of serum, total iron binding capacity of serum and percent saturation of transferrin with iron. Iron balance studies, bone marrow biopsies and tissue analyses also were performed. Under the specified conditions, 125 p.p.m. of oral iron appear adequate for the baby pig.

Use of Pyroceram Crucible Vials in Ashing Biological Materials for Spectrochemical Analysis

BASS, S. T. AND JANE CONNOR

Applied Spectroscopy 13:158. 1959. (Journal Article 2459 from the Michigan Agricultural Experiment Station)

A new glass material called Pyroceram has been developed by the Corning Glass works of Corning, New York. Some of its properties include a very low or zero thermal coefficient of expansion, high shock strength, good thermal conductivity, highly-polished surface, ease of fabrication, and resistance to corrosion by alkali substance. This paper describes the use of crucible vials made of this material, in which samples of plant material can be ashed and mixed with buffer and internal standard preliminary to spectrochemical analysis. This technique does much to reduce the problems associated with ash-powder spectrochemical methods, by eliminating the time, and the possibility of losses and contamination, involved in transferring the ash from the ashing to a mixing container.

Also described is a holder, made of transite board, which was devised to support these vessels in an upright position in the muffle furnace during the ashing period.

Summer Feeding of Dairy Cattle

HUFFMAN, C. F.

Jour. of Dairy Sci. 42:1495-1551. 1959. (Journal Article 2460 from the Michigan Agricultural Experiment Station)

Pasture is the most economical feed for dairy cattle. The application of fertilizers, especially nitrogen, increased pasture production in almost a straight line up to 300 lb. of nitrogen per acre. The grazed herbage is much more nutritious than hand-picked forage. High producing cows on excellent pastures are capable of producing up to 60 lb. of milk daily without concentration supplementation. The best use of pasture is accomplished by using rotational or some form of strip-grazing. The success of these systems depends on the use of high producing cows and a proper stocking rate. Calves are capable of using good pasture at two to four months of age, but starve on poor pasture. The use of supplemental pasture, such as Sudan grass, was shown to be advantageous during summer drought. The advantages and disadvantages of using soilage and silage for summer feeding were pointed out. The cause or causes of bloat are not known. Milk from pasture fed cows is more resistant to oxidized flavor than that from barn fed cows. In order to prevent abnormal pasture flavors, cows should be removed from pasture three to five hours prior to milking.

Trans-Olecranon Approach to the Elbow Joint

MOTOSKY, U. V.; N. R. CHOLVIN AND W. O. BRINKER

Vet. Med. 54:560-568. 1959. (Journal Article 2463 from the Michigan Agricultural Experiment Station)

1. An open approach to the posterior surface of the elbow is described. This procedure consists of transecting the olecranon process and reflecting it proximally with its muscle attachments.
2. Indications for this approach are: (1) dislocations of the elbow which cannot be reduced by ordinary procedures, (2) fractures of the elbow, either recent or old, which cannot be reduced adequately due to complicating factors, and (3) removal of broken internal fixation and replacement with new fixation.

Rates of Improvement by Progeny Testing in Dairy Herds of Various Sizes

SPECHT, L. W. AND L. D. MCGILLIARD

Jour. of Dairy Sci. 43:63-75. 1960. (Journal Article 2470 from the Michigan Agricultural Experiment Station)

Rates of genetic gain in milk production by progeny testing were examined using characteristics of Michigan Holsteins. The production records from 34,073 Holsteins on DHIA test averaged 12,237 lb. of milk and 435 lb. of fat (305-2x-ME). AI daughters numbered 5,098 from 187 bulls and averaged 12,305 lb. of milk and 444 lb. of fat. Characteristics found were: repeatability, .46 for milk, .40 for fat; heritabilities from correlations between AI paternal sisters, .31 for milk, .23 for fat; regression of future AI daughters on first n tested AI daughters, $\frac{n}{n+12}$ for milk and $\frac{n}{n+16}$ for fat; average age at calving, 4.4 years; cows

removed annually, 26.3 percent, one-tenth involuntarily in each of the first four lactations and one-fourth in later lactations; and heifers born which come into production, 70 percent.

In herds of less than 100 cows, progeny testing was less efficient in improving the rate of genetic gain than the use of young sires selected on the basis of their dams' production. In herds of 100 and 200 cows, progeny testing had a slight advantage over the latter method.

Progeny testing in AI populations of 10,000 tested cows gave possibilities of annual genetic progress of from 1.7 to 2.3 percent of the average annual yield, depending upon the number of sires sampled and the proportion of those sampled which are selected for service.

Accumulation and Elimination of Hexavalent Chromium in Rainbow Trout

KNOLL, J. AND P. O. FROMM

Physiological Zoology 33:1-8. 1960. (Journal Article 2477 from the Michigan Agricultural Experiment Station)

Rainbow trout, exposed to 2.5 mg. Cr/1. in tap water, accumulated chromium in concentrations exceeding the environment in the spleen, posterior gut, pyloric caeca, stomach and kidney. The major route of entry of hexavalent chromium into trout is probably the gills. Fish with esophageal occlusions had accumulations of chromium similar to those of normal fish in chromated water. Hexavalent chromium, given via stomach tube, was not accumulated to any degree by tissues other than those of the gastro-intestinal tract in 24 hours. Fresh-water elimination studies showed a rapid loss of chromium from the blood, liver, stomach, pyloric caeca and posterior gut, while retention occurred in the spleen and kidney.

Human consumption of the muscle portion of fish taken from waters contaminated with this or lower levels of chromium probably would represent no serious health hazard.

Site Index for Planted Red Pine by the Five-Year Growth Intercept Method

DAY, M. W.; C. F. BEY AND V. J. RUDOLPH

Jour. of Forestry 58:198-202. 1960. (Journal Article 2479 from the Michigan Agricultural Experiment Station)

Data from 56 plots in 40 different stands of red pine (*Pinus resinosa* Ait.) in Michigan and adjacent Ontario, Canada were used to determine the relationship of conventional height-over-age site index values to the evaluation of site quality by use of the five-year intercept, beginning with the first node above breast height. The stands ranged from 21 to 38 years of age, and from 33 to 88 in site index by the height-over-age method. The range in the five-year growth intercept was from 2.51 to 11.79 feet. In 84 percent of the cases, a reliable estimate of site index could be obtained by using the five-year growth intercept method. This simplified obtaining the site index for a given stand, and permits the determination of site index in young stands, even those which have grown for only five years beyond breast height.

Relative Cleanability of Various Stainless Steel Finishes After Soiling with Inoculated Milk Solids

KAUFMANN, O. W.; T. I. HEDRICK; I. J. PFLUG; C. G. PHEIL AND R. A. KEPPELER

Jour. of Dairy Sci. 43:28-41. 1960. (Journal Article 2482 from the Michigan Agricultural Experiment Station)

A semi-automatic spray washing device, which provided controlled rinsing and washing without brushing, was used to determine the relative cleanability of Type 302 stainless steel panels having a No. 2B, 3, 4, and 7 finish after soiling with skim milk inoculated with *B. globigii* spores.

Using the Direct Surface Agar Plate test at the 1 percent and 5 percent level, no significant difference was observed among these finishes after the test areas were rinsed (T-2), rinsed and washed with alkaline detergent (T-3), and rinsed, washed and sanitized (T-4). This study indicates that the less highly polished finishes can be cleaned bacteriologically to the same degree as the highly polished No. 7 surface when a recommended cleaning cycle is used.

No significant difference in cleanability was observed at the 5 percent level with the Standard Swab Contact Test after T-3 and T-4.

(2-Chloroethyl) trimethylammonium Chloride and Related Compounds as Plant Growth Substances I. Chemical Structure and Bioassay

TOLBERT, N. E.

Bio. Chem. 235:475-479. 1960. (Journal Article 2483 from the Michigan Agricultural Experiment Station)

Compounds of the structure $(CH_3)_3N+CH_2-CH_2X$ are active as plant growth substances when X is a Cl, Br or $=CH_2$ group. The trimethylamine group is necessary for activity. The length of the ethyl chain is optimum for maximum activity. Solutions of (2-chloroethyl) trimethylammonium chloride, (2-bromoethyl) trimethylammonium bromide and (2, 3-n-propylene)–trimethylammonium bromide were active at 10^{-6} M when poured on the soil. Treated wheat plants grew with shorter stems than control plants.

"Diabetic" Ice Cream

LUCAS, P. S.

Ice Cream Field, Nov. 1959 (Journal Article 2484 from the Michigan Agricultural Experiment Station)

The manufacture of so-called diabetic ice cream is not favored in Michigan because of the extreme variance in the tolerance shown by diabetics to sugar. When a sugar substitute instead of sucrose, is used, the ice cream is deprived of one-third to one-half of its solids and a very inferior product results. Most materials which might be used to replace these solids are prohibited by law, although one product, milk solids with low percent milk sugar or free of milk sugar, will give good results. Several experimental batches of ice cream were made up, scored, and their caloric value calculated. Some contained the ingredients used to supply body, but not permitted by law. Fat content of frozen desserts in Michigan must contain no more than 2.5 percent in sherberts and no less than 12 percent for ice cream, thus limiting the field in which the manufacturer must work.

Measuring Soil Moisture Tension

BOUYOUCOS, GEORGE

Agr. Engr. 41:40-41. 1960. (Journal Article Number 2493 from the Michigan Agricultural Experiment Station)

The plaster of paris electrical resistance block method was originally calibrated to read directly in percentage of available moisture in soils. It is now calibrated to read also in atmospheres of soil moisture tension or suction. It is to be emphasized here, however, that the calibration in tension is not intended to replace the present calibration in percent of available moisture, but rather to supplement it. In other words, it is an additional calibration and available to those who may wish to use it.

Improvements in Precision of High Voltage Spark Excitation Spectro-chemical Analyses of Plant Material by Changing Electrode Geometry and Sample Treatment

BASS, S. T. AND JANE CONNOR

Jour. of the Assoc. of Off'l. Agr. Chemists 43:113-115. 1960. (Journal Article 2501 from the Michigan Agricultural Experiment Station)

A comparison of all combinations of two electrode geometries with three methods of solubilizing the ash of plant materials was made in an effort to improve the spectrochemical analysis of plant ash by spark solution technique. It was found that a flat-polished electrode gave better reproducibility than the crater electrode described in "Official Methods of Analysis," A.O.A.C. It also was found that solubilizing the dry-ashed samples in HCl and evaporating to dryness before adding standard solutions gave no improvements in precision of the method.

Local Action of Oxytocin on Mammary Glands of Postpartum Rats After Litter Removal

MEITES, JOSEPH; C. S. NICOLL AND P. K. TALWALKER

Proc. of the Soc. for Expm'tl. Biology and Med. 103:118-122. 1960. (Journal Article 2506 from the Michigan Agricultural Experiment Station)

1. Since no convincing evidence exists that the action of oxytocin in maintaining mammary secretion in postpartum rats after litter removal is due to prolactin release, attempts were made to determine whether its effects were exerted directly on the mammary gland. After maintaining milk secretion in 25 such rats for five or nine days by daily injections of prolactin or twice-daily injections of oxytocin, a mammary biopsy was taken from each rat. They were then given an intraperitoneal injection of 2 IU oxytocin or physiological saline, and 10 minutes later, all except 5 rats were killed and the remainder of the previously biopsied mammary gland was removed. Mammary biopsies from the remaining five rats were taken after 10 minutes and also one, two, four and eight hours later.

2. Histological examination revealed that prior to intraperitoneal oxytocin administration, most mammary alveoli contained considerable secretion and the ducts were relatively thin; whereas, 10 minutes after oxytocin injection, the alveoli appeared shrunken or collapsed with little or no secretion, and the ducts

were widely distended with milk. No notable increase in alveolar filling followed until the eighth hour after oxytocin injection. Saline had no effect on mammary alveoli and they remained filled with secretion.

3. Ejection of milk from the alveoli into large ducts by oxytocin is believed to remove the pressure on epithelial cells which secrete milk and on blood capillaries surrounding them, permitting synthesis of more milk by circulating prolactin and other hormones. Milk ejected into ducts is believed to be gradually reabsorbed into the circulation, and some may flow back into the alveoli. These local effects of oxytocin on the mammary gland are believed to account for its ability to maintain mammary secretion in postpartum rats after litter removal.

Factors Affecting Hydraulic Removal of Manure from Concrete

McQUITTY, J. B.; J. S. BOYD AND C. M. HANSEN

Agr. Engr. 41:22-23, 27. 1960. (Journal Article 2512 from the Michigan Agricultural Experiment Station)

Tests were run to determine the effect of water pressure, spray pattern and roughness of concrete surfaces on the ability to clean concrete floors. Due to the variability of manure, a statistical analysis was set up using sand for evaluating results. A check comparing sand to manure was made and it was found that the results were very similar.

It was concluded (1) a solid spray jet is superior to the spray patters; (2) with a solid spray, increasing pressure from 60 to 80 p.s.i. resulted in a highly significant improvement in cleaning effectiveness. At 100 p.s.i. the improvement over 80 p.s.i. was significant. A pressure of 120 p.s.i. was not significantly better than 100 p.s.i. (3) the effect of surface roughness on cleaning effectiveness was negligible.

Initiation of Lactation in Rats with Hypothalamic or Cerebral Tissue

MEITES, JOSEPH; P. K. TALWALKER AND C. S. NICOLL

Proc. of the Soc. for Expm'tl. Biology and Med. 103:298-300. 1960. (Journal Article 2516 from the Michigan Agricultural Experiment Station)

Rat tissue containing the hypothalamus, cerebral tissue, kidney or liver were injected subcutaneously in saline suspension into rats for five days, after they had previously been injected with estradiol for 10 days to develop their mammary glands. Saline alone was injected into control rats. The tissue containing the hypothalamus initiated lactation in 12 out of 15 rats; cerebrum in four out of 15 rats; and liver, kidney or saline in none out of five rats each. Tissue containing the hypothalamus was injected intradermally over crop sacs of five pigeons for five days and failed to induce a response, indicating that the active principle is not prolactin. It is suggested that rat hypothalamus and possibly cerebral tissue produce release of prolactin and probably ACTH from the anterior pituitary in amounts sufficient to initiate lactation.

Genetic Determination of Sex-Specific Antigens

FOX, ALLEN S.

Jour. of the Nat. Cancer Inst. 23:1297-1311. 1959. (Journal Article 2533 from the Michigan Agricultural Experiment Station)

The results of an immunogenetic analysis of the effects of the X and Y chromosomes on tissue antigens (proteins) in *Drosophila melanogaster* are presented, and are used to formulate by analogy the genetic problems involved in the analysis of sex-specific antigens, particularly those connected with the Eichwald-Silmser effect in mice (rejection of male isografts by females). In *Drosophila,* two male-specific antigens (♂ -1 and ♂ -2) and two female-specific antigens (♀ -1 and ♀ -2) are demonstrated by means of agar-diffusion techniques. These differences between males and females are attributable to the difference in number of X chromosomes (one in males and two in females) rather than to the presence or absence of the Y chromosome, thus suggesting involvement of the sex-determining genes carried by the X. The heterochromatic Y chromosome has no detected effect on the antigenic specificity of proteins, but it does exert a maternal influence on the immunological (precipitating) and physical properties of at least one protein (Y-1). The presence or absence of a Y chromosome in the oocytes of a female prior to meiosis determines the properties of Y-1 produced in her progeny after fertilization. Thus, questions regarding X-chromosomal dosage, presence or absence of the Y chromosome, and matrocliny must all be answered in the genetic analysis of sex-specific antigens.

Some Mechanical and Rheological Properties of Grains

ZOERB, GERALD C. AND CARL W. HALL

Agr. Engr. Res. 5:83-93. 1960. (Journal Article 2550 from the Michigan Agricultural Experiment Station)

Basic mechanical and rheological physical properties of individual bean, corn and wheat kernels were determined.

Moisture content had the greatest influence on the strength properties of the grain. The compressive strength, modulus of elasticity, maximum compressive stress, and shear stress generally decreased in magnitude with an increase in moisture content. Energy requirement for impact shear was higher than static shear at high moisture. Modulus of resilience and modulus of toughness did not vary greatly with moisture change.

Stress relaxation with time was studied for three moisture levels and three deformation rates. Initial rate of deformation had more effect on the rate of stress relaxation than moisture content or the initial amount of deformation. A two-term exponential equation was obtained graphically to express the stress-relaxation-time relationship.

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The Quarterly Bulletin

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